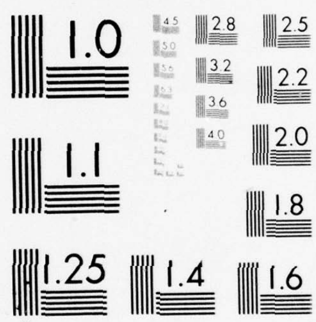
AD-A052 165 DAVID W TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CE--ETC F/G 13/2
NONOILY AQUEOUS WASTE STREAMS ON USS SIERRA (AD 18). VOLUME I.(U)
APR 74 A TALTS, D R DECKER, W HOFFMANN
UNCLASSIFIED MAT-28-818 DTNSRDC-4182 NL

| OF |
AD
A052165

END
DATE
FILMED
5-78
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20034

NONOILY AQUEOUS WASTE STREAMS ON USS SIERRA (AD 18)

Volume I

by

A. Talts and D. R. Decker

Pollution Abatement Division

and

W. Hoffmann

Operations Research Division

[redacted]

MATERIALS DEPARTMENT

Annapolis

RESEARCH AND DEVELOPMENT REPORT

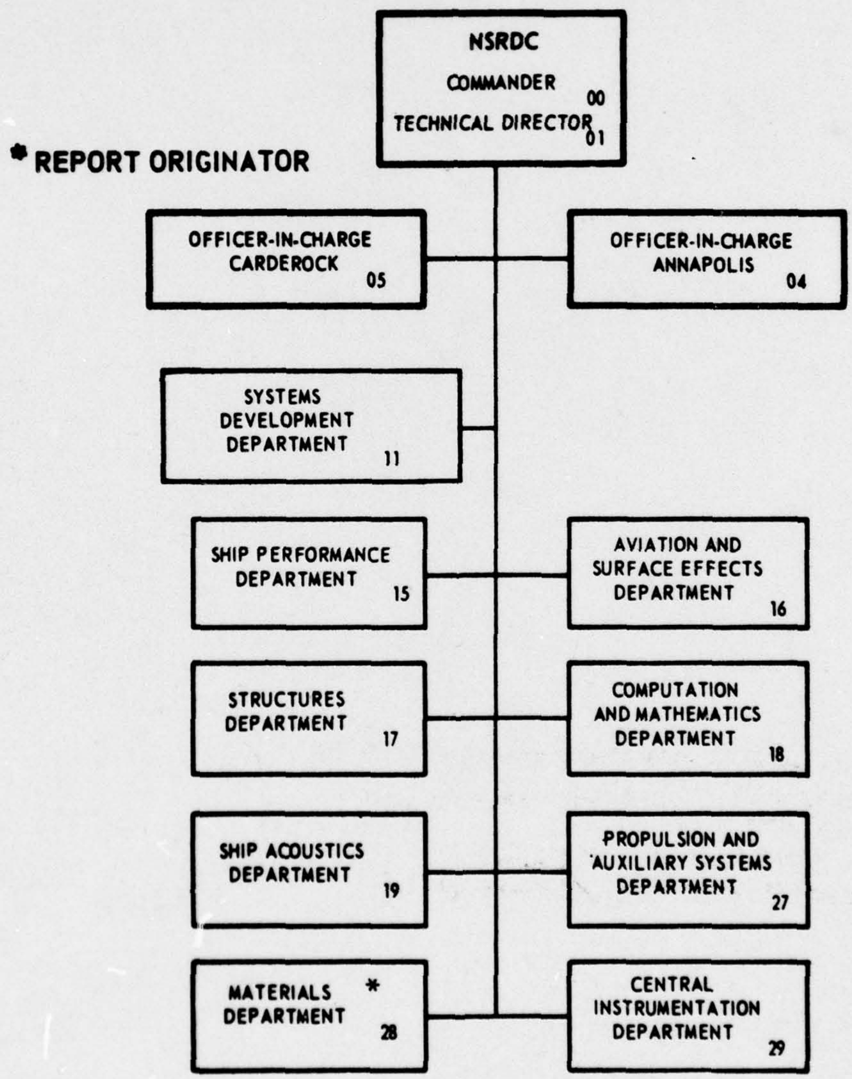
April 1974

Report 4182

The Naval Ship Research and Development Center is a U. S. Navy center for laboratory effort directed at achieving improved sea and air vehicles. It was formed in March 1967 by merging the David Taylor Model Basin at Carderock, Maryland with the Marine Engineering Laboratory at Annapolis, Maryland.

Naval Ship Research and Development Center
Bethesda, Md. 20034

MAJOR NSRDC ORGANIZATIONAL COMPONENTS



1

DEPARTMENT OF THE NAVY

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

BETHESDA, MD. 20034

6 NONOILY AQUEOUS WASTE STREAMS ON USS SIERRA (AD 18).
Volume I.

by

10 A./Talts, ~~and~~ D. R./Decker
Pollution Abatement Division
and
W./Hoffmann
Operations Research Division

9 Research and development rept,

Dis~~tribution limited to U. S. Government agencies~~
~~only; Test and Evaluation; April 1974.~~ Other
requ~~ests for this document must be referred~~ to
~~Commander, Naval Ship Systems Command~~ (SHIPS
03~~412B), Washington, D. C. 20362.~~

16 F53554 17 YF53554002

12 73p.

18 DTNSRDC

11 April 1974

14 MAT-28-818

19 Report 4182

408 635

LB

ABSTRACT

The nonoily waste-water streams aboard USS SIERRA (AD 18) originating from the crew's head, galley (and scullery), laundry, pipe shop, and print shop have been characterized. The data have been used to develop mass emission factors for selected parameters in these waste-water streams. Projections have been made to the total ship for total nonoily waste-water discharges for normal in-port operations.

Data collected aboard other ships surveyed under this program (USS O'HARE (DD 889), USS SEATTLE (AOE 3), and USS INDEPENDENCE (CV 62)) are being similarly analyzed and correlated. Corroboration and validation of mass emission factors must be accomplished by the characterization of the total flow and all subflows deriving from a ship of comparable size.

ADMINISTRATIVE INFORMATION

This work was accomplished under Task Area YF 53 554 002, Task 65502, Work Unit 1-2860-501-30.

This laboratory was tasked under the Navy Environmental Protection Data Base Program to characterize the nonoily aqueous waste streams discharged by Navy ships, reference (a). USS SIERRA (AD 18) was nominated as a survey vehicle representative of its particular class of Fleet ships, reference (b).

This report is presented in two volumes: volume I contains the details of the survey, methods, summarized results and a discussion thereof; volume II contains the complete and unabridged data and calculations.

ADMINISTRATIVE REFERENCES

(a) NCEL L70/Mv YF 38.554.002.02, ser: 59 of 13 Jan 1972
(b) COMCRUDESLANT ltr FF 4-6/hts 9360, ser: 411C/5788 of 22 Oct 1971

ACKNOWLEDGMENTS

This study required the integrated efforts of numerous managers, scientists, and engineers. The following abridged list indicates the scope of the work:

Program Manager - F. Ventriglio, NAVSHIPS (SHIPS 03412B)

Project Manager - G. B. Nickol, NSRDC (Code 2864)

Senior Project Engineer - W. van Hees, NSRDC (Code 2863)

Engineering Officer - Lt. Landis, USN, USS SIERRA (AD 18)

Project Engineer - F. S. Foust, NSRDC (Code 2863)

On-Site Laboratory Analysis -
M. W. Raupuk, NSRDC (Code 2863)
D. B. Williams, NSRDC (Code 2863)
M. A. Acampora, NSRDC (Code 2841)

Technical Assistance in Data Collection -
Bradford Computer & Systems, Incorporated
Rockville, Maryland
(G. S. Sharkins, Project Engineer)

Installation and Removal of Equipment -
J. P. Shugh, NSRDC (Code 553)
S. Bono, NSRDC (Code 553)
D. Harris, NSRDC (Code 552)
W. Weaver, NSRDC (Code 552)

Statistical Analysis and Development of Mass Emission Factors - M. Lamatrice, NSRDC (Code 1863)

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

INTRODUCTION

USS SIERRA (AD 18) was the first ship surveyed by this laboratory for the characterization of its nonoily aqueous waste streams being discharged to the environment.[1] This study was conducted as a part of one segment of the Navy Environmental Protection Data Base (NEPDB) Program. USS O'HARE (DD 889), USS SEATTLE (AOE 3), and USS INDEPENDENCE (CV 62) have subsequently been surveyed under this program as representatives of different classes of Fleet ships.[2-4] A preliminary analysis of the flow data from these four ships has been reported.[5] Final reports on each ship are in preparation.

USS SIERRA was surveyed while in port at the Naval Operations Base, Norfolk, Virginia, over the period 16 May through 9 June 1972. Nonoily wastes originating from the forward crew's head, the main crew's galley and scullery, the print shop, and the pipe shop were monitored as to flow rates and pollutant concentrations. The flow rates from the torpedo repair shop were also monitored. Survey methods and procedures have been previously detailed.[1] Volume I of this report summarizes survey methods and provides background for the tabulated results and their interpretation. Volume II, published under separate cover, contains the complete and unabridged data on flow rates, flow profiles, concentration of pollutants in waste streams, and mass emissions computed on a per capita basis and for the entire ship. Appendixes A and B of this volume provide information on the statistical methodology and examples of the data format contained in volume II.

BACKGROUND

The NEPDB Program was established to determine the effects of naval ship and shore installations on the environment, and to permit assessment of measures taken to reduce environmental impact. This laboratory's efforts include the development, accumulation, and interpretation of both qualitative and quantitative data for the pollutants content of ships' gaseous, liquid, and solid discharges. These data are to be coupled with information on ships' operations to develop models (mass emission factors) permitting quantitative prediction of all pollutants attributable to Navy ships, and to provide the necessary information for the development of waste processing/management systems and monitoring technology. Ships have been selected to represent four different

[1]Superscripts refer to similarly numbered entries in the Technical References at the end of the text.

classes in the Fleet (AD, DD, AOE, and CV). The four selected ships (USS SIERRA (AD 18), USS O'HARE (DD 889), USS SEATTLE (AOE 3), and USS INDEPENDENCE (CV 62)) were home-ported at the Naval Operations Base, Norfolk, Virginia. Surveys characterizing the nonoily waste-water generation rates and concentrations of pollutants in the streams of these ships have been completed.[1-4] Nonoily waste waters are defined in this context as all those aqueous waste streams which are neither bilge nor ballast water.

Environmental Protection Agency (EPA) Marine Sanitation Device Standards (37FR12391, 23 June 1972) require that vessels "prevent the overboard discharge of sewage, treated or untreated" within the navigable waters of the United States. The Navy's decision to install collection, holding, and transfer (CHT) systems aboard Fleet ships (CNO message 312355Z, January 1972) for the on-board retention of sanitary wastes while passing through these zones, with subsequent discharge to shore collection and treatment facilities, is in compliance with the EPA standards. Efficient design of CHT systems requires accurate waste generation-rate data for the characterization of hydraulic loadings and the concentrations of pollutants. Shore receiving and treatment facilities have corresponding requirements for the same information.

Marine on-board waste-treatment systems with no discharge capabilities are required as alternatives to CHT systems on ships operating for considerable periods within contiguous navigable waters, or remaining at anchor, or in pollution-sensitive foreign ports. The design of such systems has a primary requirement for data on nonoily waste characterization.

Shipboard nonoily aqueous wastes may be further subdivided into sanitary (soil drains), hotel (food preparation, dishwashing and laundry), and industrial (medical/dental, laboratories, and workshops).

To facilitate this distinction, individual waste sources have been codified for computerized data management as shown in table 1.[3] This coding system did not exist at the time of the actual survey of the USS SIERRA, but has subsequently been applied in the data-management process. Flowmeter readings and pollutant-concentration data, originally collected in bound log books, have been transposed to forms as shown in figures 1 and 2 for data processing.[3]

TABLE 1
ANNAPOLIS NEPDB SURVEY, NONOILY AQUEOUS WASTE SOURCES

Area	Source Code	Area	Source Code
Head	01-09	Medical/Dental	40-49
Miscellaneous	01	Medical miscellaneous	40
Commodes	02	Sick bay sink	41
Urinals	03	Operating room sink	42
Washbasin	04	Dental miscellaneous	43
Shower	05	Pharmacy	44
Deep sink	06	X-ray (medical)	45
		Medical ward head	46
Food Preparation	10-29	Medical ward diet kitchen/scullery	47
Miscellaneous	10		
Dishwasher	11	Medical ward deep sink	48
Galley deep sink	12		
Galley main drain	13	Laboratories	50-59
Kettle drain	14	Miscellaneous	50
Potato peeler	15	Photo (all sources)	51
Bake shop	16	Chemical	52
Vegetable preparation room	17	Oil shack	53
		Fuel and water test	54
Garbage grinder	18		
Scullery deep sink	19	Workshops	60-69
Scullery drain	20	Miscellaneous	60
Pot and pan room	21	Machine	61
		Pipe	62
Laundry	30-39	Shipfitters'	63
Main drain	30	Electrical/power	64
Washing machine	31	Battery	65
Deep sink	32	Print	66
Dry cleaning	33	Filter clean-up	67
		Torpedo repair	68
		Sheet metal	69
		Miscellaneous	70-79

SURVEY METHODOLOGY

SOURCES OF POLLUTION

Commencing 3 January 1972, USS SIERRA was visited by personnel from this laboratory for the purpose of defining potential sources of pollution and selecting specific flow monitoring locations and sampling ports. Table 2 contains a listing of spaces observed to be potential contributors.

The complexity of piping on USS SIERRA prohibited monitoring of all discharges; material and labor expenditures would have been excessive. Specific flow monitoring and sampling locations were selected on the basis of what was judged to be the relative importance of the particular waste water involved in terms of environmental pollution and impact. Space availability and piping accessibility were also important considerations. Furthermore, it was ascertained that only waste from a single origin would flow past a given sampling point. Based on these criteria, the sources listed in table 3 were selected for monitoring. It is anticipated that future surveys of other Fleet ships to be conducted under this program will complement this data and provide information on other source areas.

SURVEY TECHNIQUES

Installation of survey equipment began on 26 April 1972. Problems with the late arrival of some meters, with the calibration and with base line zero drift in some of the electromagnetic flowmeters, and of meter cloggings by unexpected objects, had to be overcome before monitoring could begin. Consequently, the actual survey was not started until 29 May 1972.

Conventional positive-displacement water meters, figure 3, could not be used in the discharge lines, due to the presence of components in the waste stream capable of fouling them, e.g., greases, chemicals, and suspended solids of a highly variable nature. Electromagnetic-type, unobstructed, flow-through meters, figure 4, were therefore used in discharge lines in those situations where influent water flow was not equal to effluent wastewater flow. In all other cases, nutating-disk, positive displacement meters were placed in the influent waterlines to the individual sources. The listing of meter numbers and specific locations is included as table 4. Meters in the 100 series are of the positive-displacement, nutating-disk type; those in the 200 series are of the electromagnetic flow-through type.

TABLE 2

POTENTIAL SOURCES OF NONOILY AQUEOUS WASTES ABOARD USS SIERRA

Heads - Containing a total of 65 water closets, 24 urinals, 30 showers, 114 washbasins, and 8 deep sinks.

- Crew's (5 each, 2 major)
- CPO
- Officer's (2 each)
- Warrant officer's
- Sick bay
- Galley
- Ladies' powder room

Food Preparation

- Galleys (1 each crew, CPO, Officer's, and Captain's)
- Sculleries (1 each crew, CPO, and Officer's)
- Bake shop (crew's galley area)
- Vegetable preparation room (crew's galley area)
- Pot and pan clean-up room (crew's galley area)

Laundry

- Main laundry (two 100-lb* capacity washers each and one 50-lb capacity washer each)
- Commercial dry cleaning unit

Medical/Dental

- Sick bay (minor surgical)
- Medical ward (with head (see above) and deep sink)
- Dental operating room area and prosthetic lab (not in use at time of survey)
- Pharmacy
- X-ray developers (1 each medical and dental)
- Physical therapy space

Laboratories

- Photo lab (combined with print shop)
- Chemistry lab (not in use at time of survey)
- Fuel and water test lab (laboratory test area)

Workshops

- Machine
- Pipe[1]
- Shipfitters'[1]
- Electrical
- Power (motor rewind)[1]
- Battery[1]
- Print (combined with photo lab)
- Torpedo repair[1]
- Carpenters'
- Instrument
- Calibration (fuel and water gages)
- Auxiliary fire control

[1]All shops contained washbasins; however, only those footnoted contained sinks used expressly for industrial processes.

CPO - Chief Petty Officer.

*Abbreviations used in this text are from the GPO Style Manual, 1973, unless otherwise noted.

TABLE 3

MONITORED SOURCES OF NONOILY AQUEOUS WASTES

Crew's head - Forward, main
Crew's galley (including bake shop and vegetable preparation room
Crew's scullery (including dishwasher and pot and pan room)
Laundry - Washers and deep sink (not dry cleaning unit)
Workshops - Pipe, print, and torpedo repair[1]

[1]Flow only and no samples in torpedo repair.

TABLE 4

METER NUMBERS AND LOCATIONS

Meter No.	Source Code*	Location
101	03	S, Feed to all urinals
102	01	S, Main salt-water feed to head (includes urinals and commodes)
103	01	P, Main potable water feed to head (includes washbasins, showers, deep sink, and deck wash)
104	04	P and C, Feed to two washbasins
105	04	P and C, Feed to one washbasin
106	06	P and C, Feed to head deep sink and deck flush
107	04	P and H, Feed to all washbasins
108	04	P and C, Feed to six washbasins
109	15	P, Feed to potato peeler
110	10	P, Main feed to crew's galley
111	19	P, Feed to scullery deep sink and wash down
112	11	P, Feed to dishwasher
117	68	P, Torpedo repair deep sink
118	32	P, Feed laundry deep sink
119	30	P, Main feed to entire laundry
122	31	P and C, Feed to one (of three) washing machines
123	31	P and H, Feed to one (of three) washing machines
124	62	P, Feed to pipe shop deep sink
208	19	P, Drain - scullery deep sink
213	66	P, Drain - print shop deep sink
218	21	P, Drain - pot and pan room deep sink
219	02	S, Drain - all commodes in crew's head
220	16	P, Drain - bakery deep sink
221	13	P, Drain - galley deep sink and deck drain

*Source code sequence applied is the same as for waste concentration data.

S - Salt water; P - Potable water; C - Cold water; H - Hot water

Meters were read hourly for an initial period of 2 or 3 days to establish flow profiles. Thereafter, readings were taken once in the morning and once in the evening. Calculations required to compute flows from the individual sources based on the meter readings are shown in table 5.

TABLE 5
PROCEDURES TO COMPUTE SOURCE FLOWS

Crew's Head (Source Codes 01-06)

a. Salt-water total flows - This equals the flow-through meter 102 and should be compared with the value obtained from meters 101 + 219.

b. Salt water to commodes - Equals 102 - 101; compare with 219.

c. Salt water to urinals - Equals 101; compare with 102 - 219.

d. Potable-water total flow - Equals 103.

e. Potable water to washbasins (hot and cold) - Equals 104 + 105 + 107 + 108.

f. Potable water to showers - Equals 103 - (104 + 105 + 106 + 107 + 108).

g. Potable water to head deep sink and deck wash - Equals 106.

h. Total water use in head (salt and potable) - Equals 102 + 103.

Crew's Food Preparation (Source Codes 10-21)

a. Potable water, total for food preparation - Equals 110 + 111 + 112 + 220 + 208.

b. Potable water, galley food preparation - Equals 220 + 221 - 218.

c. Potable water, scullery and clean-up (less dishwasher) - Equals 111 + 218 + 208.

d. Potable water, dishwasher - Equals 112.

Laundry (Source Codes 30-32)

a. Potable water, total use in area - Equals 119.

b. Potable water, to one washing machine (of three) - Equals 122 + 123.

c. Potable water, to deep sink - Equals 118.

Shops (Source Codes 60-68)

a. Potable water, total to pipe shop - Equals 124.

b. Potable water, total to print shop - Equals 213.

c. Potable water, total to torpedo repair shop - Equals 117.

Electromechanical flush counters were installed at the flushometers of the commodes and urinals in the crew's head. Additionally, manual counts were taken of the actual number of individual users of the head space over several days. Similarly, records were kept of the number of meals served in the galley and the number of personnel whose laundry was washed. The nature of the activity in the shop areas was logged.

Sampling valves were installed slightly offset from the underside of horizontal runs of discharge lines. Short lengths of flanged piping of either the same diameter as the discharge line, or at least one-half of the diameter, depending on the discharge line size, were used.

Samples were collected beginning 16 May 1972 in the pipe and print shops, scullery and the potable-water uses in the head. The late arrival of some meters (primarily due to manufacturer's shipping delays) resulted in the postponement of sampling from the galley and salt-water flush side of the head until 30 May 1972. All sampling (and flow monitoring) was terminated on 9 June 1972.

All sampling was carried out manually since automatic samplers for fluids carrying coarse particulates are not yet available for shipboard application. Samples are classified either as "grab" or "composite." Grab samples are collected by opening the sampling valve and collecting the discharge in a wide mouth presterilized polypropylene bottle. These samples are retained as separate entities for future analysis. Composite samples are collected in either of two ways: a time-sequenced composite requires the collection of a series (usually two to ten) of individual small grab samples into a single container. Each grab is representative of a specific time period; flow-proportioned composite samples are collected by taking a series of grab samples over a specific time interval, during which flow is also carefully monitored, and later mixing these proportionately with the flow during the collection period. In instances of low-flow or batch-type operations, a total composite was obtained by collecting the entire discharge over a given time interval, mixing and taking a subsample for analysis.

Sanitary waste samples were collected in a polyethylene container of 10-gallon capacity and macerated for 5-10 minutes to provide a uniform, smooth consistency. A subsample was then taken from this mixture for analysis.

After the samples were obtained, they were immediately put on ice in a portable ice chest and taken twice daily to the laboratory where analysis would be promptly started. Laboratory space had been made available at Norfolk Naval Base at the Environmental and Preventive Medicine Unit (EPMU) 2, which permitted rapid processing of samples, particularly for those parameters which would become degraded on standing or in refrigerated preservation. Subsamples were air-freighted (in iced containers) to Annapolis for more extensive analysis.

The distribution of samples collected from the various sources is shown in table 6. Analyses were performed for the parameters listed in table 7 according to established and standardized methodology.[6-8] Not all samples were analyzed for the total series, as indicated.

TABLE 6
SAMPLE COLLECTION AND DISTRIBUTION

Source	Source Code	No. of Samples	
		Grab	Composite
Head			
Miscellaneous	01	4	0
Commode discharge	02	88	0
Urinal discharge	03	58	0
Washbasins drains	04	67	11
Showers drains	05	11	2
Food Preparation			
Miscellaneous	10	2	0
Dishwasher drain	11	33	23
Galley main drain	13	59	8
Potato peeler drain	15	6	0
Bake shop sink drain	16	28	6
Scullery sink discharge	19	64	29
Scullery main drain	20	61	31
Pot and pan room sink drain	21	38	5
Laundry, main drain	30	62	23
Shops			
Pipe shop sink drain	62	10	24
Print shop drain	66	9	20
	Subtotal	600	182
	Total	762	

TABLE 7 - ANALYTICAL PROCEDURES

Parameters	Units of Expression	Detection Limit
pH	Units	0.02
Dissolved oxygen (DO)	mg/l	0.1
Total suspended solids (TSS)	mg/l	1.0
Total volatile suspended solids (TVSS)	mg/l	1.0
Total solids (TS)	mg/l	1.0
Total volatile solids (TVS)	mg/l	1.0
Total dissolved solids (TDS)	mg/l	1.0
Total biochemical oxygen demand (BOD_5)	mg/l	1.0
Total chemical oxygen demand (COD)	mg/l	5.0
Total organic carbon (TOC)	mg/l	1.0
Oil/grease (O/G)	mg/l	1.0
Methylene blue active substances (MBAS)	mg/l	0.05
Nitrogen, ammonia (NH_3N)	mg/l NH_3N	0.05
Nitrogen, nitrate (NO_3N)	mg/l NO_3N	0.05
Total Kjeldahl nitrogen (TKN)	mg/l TKN	0.05
Total phosphorus (PO_4P)	mg/l PO_4P	0.05
Chromium, Cr	mg/l Cr	0.02
Copper, Cu	mg/l Cu	0.02
Lead, Pb	mg/l Pb	0.02
Magnesium, Mg	mg/l Mg	0.01
Mercury, Hg	mg/l Hg	0.01
Nickel, Ni	mg/l Ni	0.02
Silver, Ag	mg/l Ag	0.01
Zinc, Zn	mg/l Zn	0.01
Total coliform	MF No./100 ml	10.0
Fecal coliform	MF No./100 ml	10.0
BOD_5, soluble	mg/l	1.0
COD, soluble	mg/l	5.0
Salinity	mg/l as NaCl	0.1
Alkalinity/acidity	mg/l as $CaCO_3$	0.1
Chlorine residual	p/m	0.1
Chloride	mg/l as Cl	0.1
Sulfate	mg/l as SO_4	1.0

*The established detection limit represents the lowest value which could be accurately determined with available methodology and instrumentation at the time of the survey.
MF - Membrane filter.

Note: Concentrations in all tables are expressed in the units listed in table 6, except where otherwise noted. A dash through the space in a table indicates insufficient data or no computation necessary. TVSS and TVS are expressed as decimal fractions of TSS and TS, respectively.

RESULTS

Volume II contains the complete data on flowmeter readings for the entire survey period and displays of flow profiles for individual point sources of liquid wastes which were monitored. It also contains all of the laboratory data on the concentrations of pollutants as analyzed in the collected samples. Appendix A of this volume provides a description of the computation procedure which was applied to the hydraulic data, a summary of results, and examples of the data presentation as it appears in volume II. Appendix B accomplishes the same purposes for the laboratory data on the concentrations of pollutants. The following sections include the combined and summarized information on each source monitored, including computed mass emission factors.

CREW'S HEAD

Figure 5 shows schematic outlines of the salt- and potable water systems in the space. A total of 240 crew's berths were assigned to utilize this space. While in port, approximately 175 were on board; 65 crew members maintained permanent quarters off the ship. Table 8 contains summarized information on salt water (sanitary only) usage.

TABLE 8
SALT-WATER USAGE IN CREW'S HEAD

	Commodes	Urinals
Counted No. of users	85 (70-96)	85 (70-96)
Total average gallons per day (gal/D)	472.6	70.9
No. of flushes per day	151 (66-305)	76 (35-179)
Gallons per flush	3.12	0.93
No. of flushes per user	1.77	0.89
Gallons per user	5.6	0.8
Total salt water, gallons per capita day (gal/C/D) = 6.4.		

The usage frequency and distribution is explained by the in-port noncaptive population situation and the physical configuration of the head (i.e., the head space contained two urinals and eight commodes and it is noted that commode uses were not all for the assumed explicit purpose intended).

Grab samples collected from the discharge lines of the commodes and urinals contained concentrations of pollutants, as shown in table 9 (selected major pollutants only are included in table 9; see volume II for details of these and other parameters).

TABLE 9

COMMODES AND URINALS, AVERAGE CONCENTRATION OF POLLUTANTS

	Commodes		Urinals		Total Weighted Average*	
	Concentration	Lb/C/D	Concentration	Lb/C/D	Concentration	Lb/C/D
pH	8.61	-	8.80	-	8.63	-
DO	3.46	-	3.24	-	3.43	-
TSS	1,789	8.38×10^{-2}	979	6.53×10^{-3}	1,688	9.01×10^{-2}
TVSS	0.77	-	0.43	-	0.73	-
TS	22,282	-	17,043	-	21,627	-
TVS	0.40	-	0.30	-	0.44	-
TDS	19,040	-	16,408	-	18,711	-
BOD_5	1,124	5.25×10^{-2}	1,172	7.82×10^{-3}	1,130	6.03×10^{-2}
COD	3,904	1.823×10^{-1}	2,634	1.76×10^{-2}	3,745	1.999×10^{-1}
TOC	1,020	4.76×10^{-2}	2,252	1.50×10^{-2}	1,174	6.27×10^{-2}
O/G	1,227	5.73×10^{-2}	727	4.85×10^{-2}	1,164	6.22×10^{-2}
MBAS	6.6	3.08×10^{-4}	2.5	1.67×10^{-5}	6.09	3.25×10^{-4}
NH_3N	366	1.71×10^{-2}	673	4.49×10^{-3}	404	2.16×10^{-2}
NO_3N	1.1	5.14×10^{-5}	2.2	1.47×10^{-5}	1.24	6.62×10^{-5}
TKN	398	1.58×10^{-2}	203	1.35×10^{-3}	321.13	1.71×10^{-2}
PO_4P	120	5.60×10^{-3}	55	3.67×10^{-4}	112	5.97×10^{-3}
Total coliform	1.16×10^{8}	-	7.88×10^{4}	-	1.02×10^{8}	-
Fecal coliform	1.83×10^{7}	-	1.57×10^{3}	-	1.60×10^{7}	-
Salinity	12,244	-	12,324	-	12,254	-

*Based on values as shown in table 8.

Note: A dash through the space indicates either insufficient data to perform the computation or that the computation could not be performed due to the nature of the data. TVSS and TVS are expressed as a decimal fraction of TSS and TS, respectively.

Lb/C/D - Pounds per Capita per Day.

Potable-water usage in the crew's head space is summarized in table 10; concentrations of major selected pollutants are contained in table 11.

TABLE 10 - POTABLE-WATER USAGE IN CREW'S HEAD

	Washbasins	Showers
Gal/D	351.5	876.3
Gal/C/D (based on 85 users as cited above)	4.1	10.3
Total potable-water usage, gal/C/D	14.4*	

*In the head deep sink and deck washdown, 28.4 gallons of potable water per day (0.4 gal/C/D) were used. This item is not included in the head total potable-water usage summary data presented herein.

TABLE 11

WASHBASINS AND SHOWERS, AVERAGE CONCENTRATION OF POLLUTANTS

	Washbasins		Showers		Total Weighted Average	
	Concentration	Lb/C/D*	Concentration	Lb/C/D*	Concentration	Lb/C/D*
pH	7.4	-	6.64	-	6.86	-
DO	2.79	-	1.12	-	1.60	-
TSS	88	3.0×10^{-3}	131	11.46×10^{-3}	119	14.3×10^{-3}
TVSS	0.58	-	0.64	-	0.62	-
TS	331	1.13×10^{-2}	345	3.02×10^{-2}	341	4.1×10^{-2}
TVS	0.51	-	0.43	-	0.45	-
TDS	269	9.2×10^{-3}	208	1.8×10^{-2}	225	2.71×10^{-2}
BOD_5	109	3.7×10^{-3}	157	1.38×10^{-2}	144	1.73×10^{-2}
COD	243	8.3×10^{-3}	328	2.88×10^{-2}	304	3.66×10^{-2}
TOC	163	5.56×10^{-3}	-	-	-	-
O/G	220	7.48×10^{-3}	-	-	-	-
MBAS	0.30	1.02×10^{-5}	-	-	-	-
NH_3N	0.69	2.34×10^{-5}	-	-	-	-
NO_3N	0.36	1.22×10^{-5}	-	-	-	-
TKN	2.24	7.61×10^{-5}	-	-	-	-
PO_4P	14.49	4.93×10^{-4}	-	-	-	-
Total coliform	8.7×10^{4}	-	5.01×10^{4}	-	6.06×10^{4}	-
Fecal coliform	2.4×10^{3}	-	1.01×10^{4}	-	7.9×10^{3}	-
Salinity	83	-	88	-	86	-

*Based on values from table 10.

Overall weighted average concentrations of pollutants in the total discharge from the head space (commodes, urinals, washbasins, and showers), based on 20.8 gal/C/D, made up of respective proportions of individual flows, are presented in table 12.

Flow-rate distribution as a function of time over a 24-hour period for total water usage in the head space is illustrated in figure 6. Note that the straight line flow rate during overnight hours is a mean value for elapsed flow between the last meter reading of the evening and the first of the morning. This occurs in all source-area flow-rate graphs. In several subsequent flow-rate graphs, the minimum envelope does not appear since it is equal to zero.

TABLE 12
TOTAL HEAD DISCHARGE, WEIGHTED AVERAGE

	Concentration	Lb/C/D*
pH	7.43	-
DO	2.16	-
TSS	599	1.05×10^{-1}
TVSS	0.66	-
TS	6860	-
TVS	0.46	-
TDS	5900	-
BOD_5	448	7.77×10^{-2}
COD	1363	2.37×10^{-1}
TOC**	779	6.83×10^{-2}
O/G**	710	6.22×10^{-2}
MBAS**	4.14	3.6×10^{-4}
NH_3N**	247	2.16×10^{-2}
NO_3N**	0.90	7.89×10^{-5}
TKN	197	1.72×10^{-2}
PO_4P	74	6.48×10^{-3}
Total coliform	3.1×10^{7}	-
Fecal coliform	5.6×10^{6}	-
Salinity	3831	-

*Based on values as shown in tables 8-11.
**Based on urinals, commodes, and washbasins.

CREW'S FOOD PREPARATION

Item (a) of figure 7 is a schematic outline of the crew's galley water uses which were monitored. Item (b) is of the bake shop, and item (c) is of the scullery.

There was an average of 1396 (range 791-1747) meals served per day in the crew's galley. During the survey, enlisted personnel from ships moored alongside USS SIERRA also used these facilities, and the fraction of the ship's crew using shore facilities cannot be directly accounted for.

Meal services were distributed as follows:

- Breakfast - 327 (range 166-433).
- Lunch - 578 (range 245-815).

- Supper - 388 (range 257-490).
- Midrations - 103 (range 87-135).

On this basis, the average number of men served per day is calculated to be 431, which is the value used for further computations. Table 13 contains summarized data on water usage for crew's food preparation. Table 14 shows the concentrations of selected major pollutants, in the three major sources monitored, and calculated weighted averages.

TABLE 13
CREW'S FOOD PREPARATION, WATER USAGE

	Gal/D	Gal/C/D*
Galley and food preparation	3350	7.77
Scullery (less dishwasher)	1919	4.45
Dishwasher	936	2.17
Total for food preparation	6205	14.4

*Based on 431 men per day.

TABLE 14
CREW'S FOOD PREPARATION, AVERAGE CONCENTRATION OF POLLUTANTS

	Galley*		Scullery**		Dishwasher		Total Weighted Average***	
	Concentration	Lb/C/D	Concentration	Lb/C/D	Concentration	Lb/C/D	Concentration	Lb/C/D
pH	7.1	-	6.62	-	9.46	-	7.20	-
DO	4.65	-	3.39	-	5.92	-	4.15	-
TSS	432	2.80×10^{-2}	940	3.49×10^{-2}	204	3.69×10^{-3}	655	6.67×10^{-2}
TVSS	0.83	-	0.87	-	0.72	-	0.83	-
TS	8,323	5.40×10^{-1}	5,473	2.03×10^{-1}	1,541	2.79×10^{-2}	5,622	7.72×10^{-1}
TVS	0.54	-	0.76	-	0.53	-	0.61	-
TDS	7,629	4.95×10^{-1}	4,620	1.72×10^{-1}	1,442	2.61×10^{-2}	4,890	6.94×10^{-1}
BOD_5	649	4.21×10^{-2}	1,845	6.86×10^{-2}	441	8.0×10^{-3}	1,210	1.19×10^{-1}
COD	1,824	1.18×10^{-1}	4,849	1.80×10^{-1}	1,034	1.87×10^{-2}	2,940	3.18×10^{-1}
TOC	362	2.35×10^{-2}	1,595	5.93×10^{-2}	263	4.77×10^{-3}	854	1.19×10^{-1}
O/G	432	2.80×10^{-2}	1,495	5.55×10^{-2}	582	1.06×10^{-2}	793	9.43×10^{-2}
MBAS	0.56	3.63×10^{-5}	1.33	4.94×10^{-5}	1.05	1.90×10^{-5}	1.02	1.05×10^{-4}
NH_3N	3.40	2.21×10^{-4}	8.64	3.21×10^{-4}	0.75	1.36×10^{-5}	3.97	5.57×10^{-4}
NO_3N	1.21	7.85×10^{-5}	1.05	3.90×10^{-5}	1.01	1.83×10^{-5}	1.49	1.36×10^{-4}
TKN	3.08	2.0×10^{-4}	45.04	1.67×10^{-3}	3.64	6.6×10^{-5}	15.0	1.94×10^{-3}
PO_4P	7.02	4.55×10^{-4}	92.09	3.42×10^{-3}	710.82	2.01×10^{-3}	50.1	5.89×10^{-2}
Total coliform	29,941	-	39,049	-	43,136	-	34,743	-
Fecal coliform	1,286	-	3,389	-	206.25	-	1,082	-
Salinity	4,770	-	717	-	123	-	2,125	-

*Includes bake shop, galley, and potato peeler.
**Includes scullery feed and drain, and pot and pan clean-up room.
***Based on values as shown in table 13.

Flow-rate distribution over a 24-hour period for the total water usage in the crew's food preparation is illustrated in figure 8.

LAUNDRY

A schematic outline of water uses in the ship's laundry is shown in figure 9. Normal operating hours were from 0730 to approximately 1600, depending on work load, for an assigned crew of 12. The ship's laundry maintained a log of pounds of wash submitted by divisions. By using a known value of the number of men per division, it was established that on the average the contributions of 413 men were washed daily. The total average daily water flow to the laundry was 1811 gal/D, which calculates to be 4.4 gal/C/D. Flow-rate distribution over a 24-hour period is shown in figure 10. The concentrations of selected pollutants measured in samples from the main drain are summarized in table 15.

TABLE 15
LAUNDRY, AVERAGE CONCENTRATION OF POLLUTANTS

	Concentration	Lb/C/D*
pH	8.52	-
DO	6.17	-
TSS	128	4.7×10^{-3}
TVSS	0.78	-
TS	769	2.82×10^{-2}
TVS	0.44	-
TDS	698	2.57×10^{-2}
BOD_5	137	5.03×10^{-3}
COD	474	1.74×10^{-2}
TOC	189	6.95×10^{-3}
O/G	227	8.34×10^{-3}
MBAS	0.67	2.46×10^{-5}
NH_3N	1.75	6.43×10^{-5}
NO_3N	1.39	5.11×10^{-5}
TKN	12.97	4.77×10^{-4}
PO_4P	27.69	1.02×10^{-3}
Total coliform	494	-
Salinity	54	-

*Based on 4.4 gal/C/D.

INDUSTRIAL AREAS

Pipe Shop

Figure 11 is a water-use schematic outline. The one sink located in this area served as a "catch-all" for both the pipe shop and the immediately adjacent sheet-metal shop. Sink uses included the degreasing of metal parts with organic solvents and water and quenching of metals, as well as domestic purposes. Normal hours in port were from 0730 to 1600 daily for an assigned crew of six men. The average daily flow of 80 gal/D was distributed over 24 hours, as shown in figure 12. Table 16 summarizes data on selected pollutants concentrations.

TABLE 16
PIPE SHOP, AVERAGE CONCENTRATION OF POLLUTANTS

	Concentration	Lb/D*
pH	8.74	-
DO	6.81	-
TSS	244	1.63×10^{-1}
TVSS	0.62	-
TS	1,358	9.07×10^{-1}
TVS	0.61	-
TDS	1,202	8.03×10^{-1}
BOD_5	2,082	1.39
COD	4,361	2.91
TOC	501	3.35×10^{-1}
O/G	394	2.63×10^{-1}
MBAS	5.63	3.76×10^{-3}
NH_3N	2.20	1.47×10^{-3}
NO_3N	0.83	5.54×10^{-4}
TKN	11.70	7.82×10^{-3}
PO_4P	13.21	8.82×10^{-3}
Cr	1.50	1.00×10^{-3}
Cu	0.72	4.81×10^{-4}
Pb	0.15	1.00×10^{-4}
Mg	4.40	2.94×10^{-3}
Hg	1.23	8.92×10^{-4}
Ni	0.26	1.74×10^{-4}
Ag	0.12	8.02×10^{-5}
Zn	1.18	7.88×10^{-4}
Total coliform	29,096	-
Salinity	76	-

*Based on 80 gal/D.
Lb/D - Pounds per day.

The concentration data for metals presented in table 16 is based on the mean value obtained from those samples analyzed which had concentrations above the detection limit, as shown in table 7. A significant percentage of all samples had concentration values below these detection limits, table 17. Hence, the value reported in table 16 (and used for subsequent computations) may be taken as the average worst-case situation.

TABLE 17
PRINT AND PIPE SHOPS, METALS ANALYSES

Metal	Detection Limit, mg/l	Below Detection Limit, %	
		Pipe Shop	Print Shop
Chromium	0.02	44	85
Copper	0.02	0	0
Lead	0.02	33	33
Magnesium	0.01	0	0
Mercury	0.01	75	85
Nickel	0.02	50	33
Silver	0.01	85	62
Zinc	0.01	0	0

Print Shop

The print shop water-use was confined to one sink, as shown in figure 13. Normal hours in port were from 0730 to 1600 daily, with an assigned crew of eight men. This shop also served as the photo lab for the ship. The sink, therefore, intermittently received discharges of waste from photo- and print-developing solutions, plus the normal products of domestic uses. Flow averaged 9.5 gal/D; the 24-hour profile is shown in figure 14. Table 18 contains a summary of concentrations of selected pollutants as measured in the discharge drain. See table 17 for the percentile of samples analyzed for metals which had values below the set detection limits.

Torpedo Repair Shop

This shop was used from 0730 to 1600 daily by an assigned crew of 20 men. The one sink, figure 15, was used for cleaning of parts and for domestic purposes. An average daily flow of 9.2 gal/D was distributed, as shown in figure 16. Samples were not collected from the discharge line at the insistence of the officer in charge.

TABLE 18
PRINT SHOP, AVERAGE CONCENTRATION OF POLLUTANTS

	Concentration	Lb/D*
pH	7.99	-
DO	3.65	-
TSS	416	3.30×10^{-2}
TVSS	0.54	-
TS	7,120	5.65×10^{-1}
TVS	0.55	-
TDS	6,843	5.43×10^{-1}
BOD_5	1,743	1.38×10^{-1}
COD	10,700	8.49×10^{-1}
TOC	1,516	1.20×10^{-1}
O/G	992	7.87×10^{-2}
MBAS	2.69	2.13×10^{-4}
NH_3N	575	4.56×10^{-2}
NO_3N	1.30	1.03×10^{-4}
TKN	92.13	7.31×10^{-3}
PO_4P	14.88	1.18×10^{-3}
Cr	0.52	4.12×10^{-5}
Cu	5.52	4.38×10^{-4}
Pb	0.10	7.93×10^{-6}
Mg	8.20	6.50×10^{-4}
Hg	0.04	3.17×10^{-6}
Ni	0.27	2.14×10^{-5}
Ag	4.53	3.59×10^{-4}
Zn	2.25	1.78×10^{-4}
Total coliform	88,262	-
Salinity	2,216	-

*Based on 9.5 gal/D.

DISCUSSION

On the basis of the presented data, coupled with information on the ship's in-port, on-board population distribution, it is possible to project the total sanitary and hotel waste-water generation rates to the entire ship, as shown in table 19. The accuracy of this projection must be considered relative to the extension of data, collected from a limited number of monitored sources, to the discharges from the entire ship. The projected gal/D value and subsequent computations are based on a total ship's complement of 825 men distributed as follows: 90% on board from 0800-1600; 45% on board from 1600-0800 the following day.* This results in an adjusted man-day value of 490, which may be used for further computations.

*This population distribution has been verified on USS FULTON (AS 11) while in port at New London, Connecticut (unpublished data).

TABLE 19
SANITARY AND HOTEL WASTES, TOTAL SHIP PROJECTION

	Gal/C/D	Projected, gal/D
Head		
Salt-water flush	6.4	3,136
Potable-water uses	14.4	7,056
Food preparation, total	14.4	7,056
Laundry	4.4	2,156
Total	39.6	19,404

Particular care must be taken in the interpretation or subsequent application of this total ship's projected data. Development of the gal/C/D data is based on population counts which are subject to interpretation. In the crew's head, the counted number of individual users, 85 of the 250 crew ostensibly assigned to the space, were not monitored as to the distribution of uses within the space itself, other than by the electromechanical counters on the commodes and urinals (see table 8). The food preparation values cited in tables 13 and 19 are based on the ship's record of the number of meals served, and makes no distinction as to the number of individuals or their origin (i.e., from ships alongside, for example).

The gal/C/D value established for the laundry is based on the ship's record of the number of men assigned to the various divisions, whose laundry was done on any day. It does not distinguish the number or distribution of individual users. The total ship's projection, as above, assigns an equal use of all functions uniformly to the entire crew, based on gal/C/D values which were derived on the basis of uncontrolled groups of individual users. This projection would be more valid if applied to the total ship's complement while at sea (i.e., a captive population); however, under those circumstances the gal/C/D values would most likely also be significantly different.

The hydraulic contributions of the three industrial shops monitored have been shown to total less than 100 gal/D on the average. Other nonoily liquid waste sources not specifically monitored (see table 2) were usually not in use due to the

availability of these services on shore, or were low-flow areas. If one assumes that the remainder of the shops contributed 100% of the flow measured in the three activities which were monitored, then the total flow would still be less than 5% of the sanitary and hotel waste flows. As such, this subtotal is overlooked in the 24-hour total ship's projected flow profile shown in figure 17.

Concentrations of selected pollutants as projected for the total ship's discharge based on head, food preparation, and laundry waste-stream contributions are summarized in table 20.

TABLE 20
PROJECTED TOTAL SHIP, AVERAGE CONCENTRATION OF POLLUTANTS

	Concentration				Projected
	Total Head	Food Preparation	Laundry	Weighted Average*	Total** lb/D
pH	7.41	7.20	8.52	7.50	-
DO	2.16	4.15	6.17	3.43	-
TSS	601	655	128	533	86.32
TVSS	0.66	0.83	0.78	0.73	-
TS	6890	5,622	769	6,048	979.99
TVS	0.46	0.61	0.44	0.51	-
TDS	5913	4,890	698	5,347	866.23
BOD_5	447	1,210	137	608	98.5
COD	1363	2,940	474	1,726	279.65
TOC	779	854	189	791	128.21
O/G	710	793	227	683	110.73
MBAS	4.14	1.02	0.67	2.58	0.42
NH_3N	247	3.97	1.75	133	21.49
NO_3N	0.90	1.49	1.39	1.04	0.17
TKN	197	15.0	12.97	111	18.06
PO_4P	74	50.1	28	60	9.69
Total coliform	$3.1x10^7$	34,743	494	176,862	-
Fecal coliform	$5.6x10^6$	1,082	-	-	-
Salinity	3831	2,125	54	2,996	485.37

*Projection based on tables 12, 14, and 15.
**Based on table 19.

The contributions of the three industrial shops monitored to the total ship's nonoily liquid waste discharge are summarized in table 21. Pounds per day values included for selected parameters are based on tables 16 and 18.

TABLE 21
INDUSTRIAL SHOPS, CONTRIBUTIONS OF POLLUTANTS (LB/D)

	Shop			Total
	Pipe	Print	Torpedo Repair	
Flow, gal/D	80	9.5	9.2	98.7
TSS	1.63×10^{-1}	0.33×10^{-1}	-	1.96×10^{-1}
TS	9.07×10^{-1}	5.65×10^{-1}	-	14.72×10^{-1}
TDS	8.03×10^{-1}	5.43×10^{-1}	-	13.46×10^{-1}
BOD_5	1.39	1.38×10^{-1}	-	2.77
COD	2.91	8.49×10^{-1}	-	1.14
TOC	3.35×10^{-1}	1.20×10^{-1}	-	4.55×10^{-1}
O/G	2.63×10^{-1}	0.787×10^{-1}	-	3.42×10^{-1}
MBAS	3.76×10^{-3}	0.213×10^{-3}	-	3.97×10^{-3}
NH_3N	1.47×10^{-3}	45.6×10^{-3}	-	47.07×10^{-3}
NO_3N	5.54×10^{-4}	1.03×10^{-4}	-	6.57×10^{-4}
TKN	7.82×10^{-3}	7.31×10^{-3}	-	15.13×10^{-3}
PO_4P	8.82×10^{-3}	1.18×10^{-3}	-	10×10^{-3}
Cr	1.0×10^{-3}	0.041×10^{-3}	-	1.041×10^{-3}
Cu	4.81×10^{-4}	4.38×10^{-4}	-	9.19×10^{-4}
Pb	1.0×10^{-4}	0.079×10^{-4}	-	1.079×10^{-4}
Hg	2.94×10^{-3}	0.65×10^{-3}	-	3.59×10^{-3}
Ni	1.74×10^{-4}	0.214×10^{-5}	-	1.95×10^{-5}
Ag	8.02×10^{-5}	35.9×10^{-4}	-	4.392×10^{-4}
Zn	7.88×10^{-4}	1.78×10^{-4}	-	9.66×10^{-4}

It is beyond the scope of this report to consider further various possible approaches at interpretation of these data. The approach used herein has been directed at presenting the greatest amount of available information as concisely as possible as intended for general purposes. Specific other uses of the data may be satisfied by appropriate adjustments of the computer programs, as discussed in the appendixes.

CONCLUSIONS

The nonoily waste-water streams on USS SIERRA (AD 18) originating from the crew's head, galley (and scullery), laundry, and pipe, print, and torpedo repair shops have been characterized.

The data have been used to compute mass emission factors for selected parameters in these waste streams.

Data collected from a limited number of representative sources have been used to make projections of the total ship's nonoily waste-water generation rates and concentrations for normal in-port operations.

RECOMMENDATIONS

The mass emission factors thus far developed require corroboration, particularly since, to date, ship's total flows have been projected from data based on selected segments of an individual ship's waste-water flows. It is recommended that a ship, comparable in size and scope of operations to those previously surveyed, be totally characterized in order to validate these extrapolations.

TECHNICAL REFERENCES

1 - Foust, F. S., et al, "Characterization of Non-Oily Waste Water Streams on USS SIERRA (AD 18)," NSRDC Rept 28-423 (28 Sep 1972)

2 - Foust, F. S., and D. R. Decker, "Characterization of Non-Oily Waste Water Streams on USS O'HARE (DD 889)," NSRDC Rept 28-501 (26 Jan 1973)

3 - Decker, D. R., and A. Talts, "Characterization of Non-Oily Waste Water Streams Aboard USS SEATTLE (AOE 3); Preliminary Report of," NSRDC Rept 28-683 (15 May 1973)

4 - Talts, A., and D. R. Decker, "Preliminary Report on the Characterization of Non-Oily Waste Water Streams Aboard USS INDEPENDENCE (CV 62)," NSRDC Rept 28-783 (20 Sep 1973)

5 - Talts, A., and W. F. Hoffmann, "Preliminary Data on Shipboard Non-Oily Waste Water Generation Rates from Four Fleet Ships Monitored Under the Navy Environmental Protection Data Base Program," NSRDC Rept 28-821 (16 July 1973)

6 - Tarras, M. J., et al, eds., Standard Methods for the Examination of Water and Wastewater, 13th Ed., New York, American Public Health Association (1971)

7 - Environmental Protection Agency, Methods for Chemical Analysis of Water and Wastes, Cincinnati, Ohio (1971)

8 - Slavin, W., Atomic Absorption Spectroscopy, New York, John Wiley & Sons (1968)

CARD 1

UIC [1] [2] [3] [4] [5] Date [7] [8] [9] [10] [11] [12] (Year, Month, Day)

Source Code [14] [15]

Time: Start [17] [18] [19] [20] Time: Finish [21] [22] [23] [24]

Sample Type [25] (G or C) Page No. [26] [27] [28]

Continuation [29] 1

DESCRIPTOR	UNIT	VALUE								
pH	UNIT	30	31	32	33	34	35	36	37	38
DO	mg/l	39	40	41	42	43	44	45	46	47
Turbidity	JTU	48	49	50	51	52	53	54	55	56
Total Suspended Solids	mg/l	57	58	59	60	61	62	63	64	65
Total Volatile Suspended Solids	mg/l	66	67	68	69	70	71	72	73	74

CARD 2 Page No. [26] [27] [28] Continuation [29] 2

Total Solids	mg/l	30	31	32	33	34	35	36	37	38
Total Volatile Solids	mg/l	39	40	41	42	43	44	45	46	47
Total Dissolved Solids	mg/l	48	49	50	51	52	53	54	55	56
Settleable Solids	mg/l	57	58	59	60	61	62	63	64	65
BOD_5 - Total	mg/l	66	67	68	69	70	71	72	73	74

CARD 3 Page No. [26] [27] [28] Continuation [29] 3

COD - Total	mg/l	30	31	32	33	34	35	36	37	38
TOC	mg/l	39	40	41	42	43	44	45	46	47
Oil and Grease	mg/l	48	49	50	51	52	53	54	55	56
Phenols	mg/l	57	58	59	60	61	62	63	64	65
MBAS	mg/l	66	67	68	69	70	71	72	73	74

CARD 4 Page No. [26] [27] [28] Continuation [29] 4

N-Ammonia	mg/l NH_3-N	30	31	32	33	34	35	36	37	38
N-Nitrate	mg/l NO_3-N	39	40	41	42	43	44	45	46	47
N-Nitrite	mg/l NO_2-N	48	49	50	51	52	53	54	55	56
Total Kjeldahl	mg/l N	57	58	59	60	61	62	63	64	65
Orthophosphate	mg/l P	66	67	68	69	70	71	72	73	74

CARD 5 Page No. [26] [27] [28] Continuation [29] 5

Total Phosporus	mg/l P	30	31	32	33	34	35	36	37	38
Aluminum	mg/l	39	40	41	42	43	44	45	46	47
Arsenic	mg/l	48	49	50	51	52	53	54	55	56
Barium	mg/l	57	58	59	60	61	62	63	64	65
Cadmium	mg/l	66	67	68	69	70	71	72	73	74

CARD 6 Page No. [26] [27] [28] Continuation [29] 6

DESCRIPTOR	UNIT	VALUE								
Calcium	mg/l	30	31	32	33	34	35	36	37	38
Chromium	mg/l	39	40	41	42	43	44	45	46	47
Copper	mg/l	48	49	50	51	52	53	54	55	56
Iron	mg/l	57	58	59	60	61	62	63	64	65
Lead	mg/l	66	67	68	69	70	71	72	73	74

CARD 7 Page No. [26] [27] [28] Continuation [29] 7

Magnesium	mg/l	30	31	32	33	34	35	36	37	38
Manganese	mg/l	39	40	41	42	43	44	45	46	47
Mercury	mg/l	48	49	50	51	52	53	54	55	56
Nickel	mg/l	57	58	59	60	61	62	63	64	65
Potassium	mg/l	66	67	68	69	70	71	72	73	74

CARD 8 Page No. [26] [27] [28] Continuation [29] 8

Selenium	mg/l	30	31	32	33	34	35	36	37	38
Silver	mg/l	39	40	41	42	43	44	45	46	47
Sodium	mg/l	48	49	50	51	52	53	54	55	56
Zinc	mg/l	57	58	59	60	61	62	63	64	65
Total Coliform	MF-#/100 ml	66	67	68	69	70	71	72	73	74

CARD 9 Page No. [26] [27] [28] Continuation [29] 9

Fecal Coliform	MF-#/100ml	30	31	32	33	34	35	36	37	38
Standard Plate Count	#/100 ml	39	40	41	42	43	44	45	46	47
TNT	mg/l	48	49	50	51	52	53	54	55	56
Cyanide	mg/l	57	58	59	60	61	62	63	64	65
Radionuclides	picocuries	66	67	68	69	70	71	72	73	74

CARD 10 Page No. [26] [27] [28] Continuation [29] 10

BOD_5 - soluble	mg/l	30	31	32	33	34	35	36	37	38
COD - soluble	mg/l	39	40	41	42	43	44	45	46	47
Salinity	mg/l NaCl	48	49	50	51	52	53	54	55	56
Alkalinity/ Acidity	mg/l Ca CO_3	57	58	59	60	61	62	63	64	65
Chlorine Residual	ppm	66	67	68	69	70	71	72	73	74

CARD 11 Page No. [26] [27] [28] Continuation [29] 11

Chloride	mg/l Cl^-	30	31	32	33	34	35	36	37	38
Sulfate	mg/l SO_4	39	40	41	42	43	44	45	46	47
	mg/l	48	49	50	51	52	53	54	55	56
	mg/l	57	58	59	60	61	62	63	64	65
	mg/l	66	67	68	69	70	71	72	73	74

NDW-NSRDC 6240/1

Figure 1
Liquid Waste Analysis Record, Naval Ships

UIC						METER NUMBER							SOURCE CODE			DATE							TIME (0000 - 2400)					METER READING										*
																YR		MO		DAY																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39

*If METER TROUBLE has occured, enter "p"

GPO 943-282

NDW-NSRDC 6240/2

Figure 2
Liquid Waste Flow Record, Naval Ships

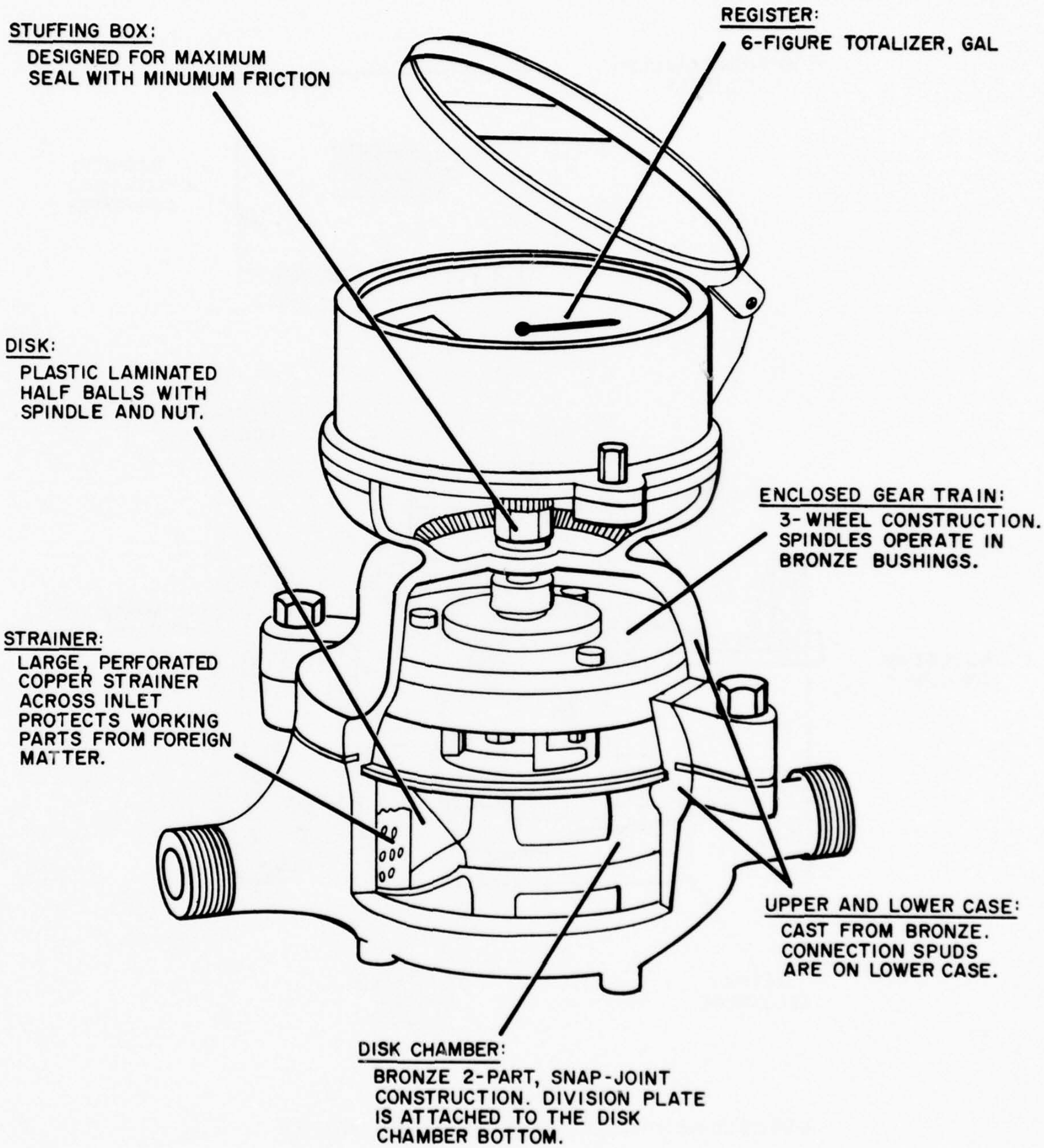
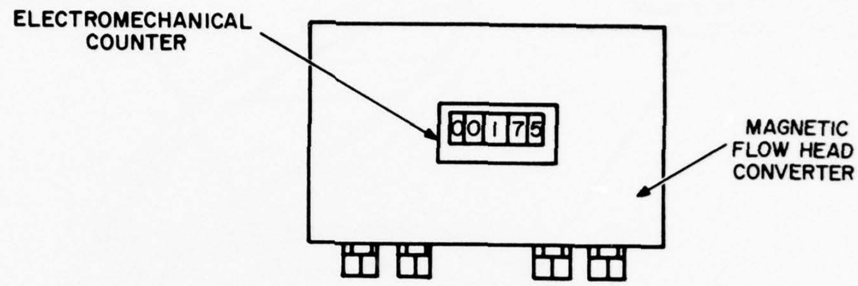


Figure 3
Nutating-Disk, Positive-Displacement-Type Water Meter



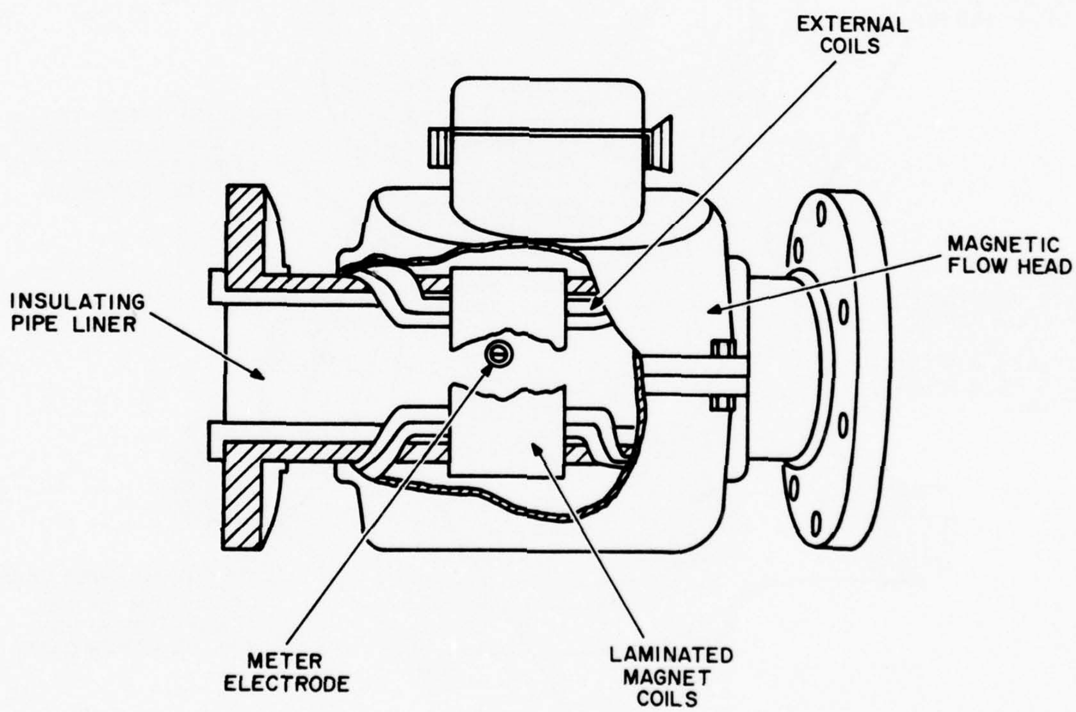
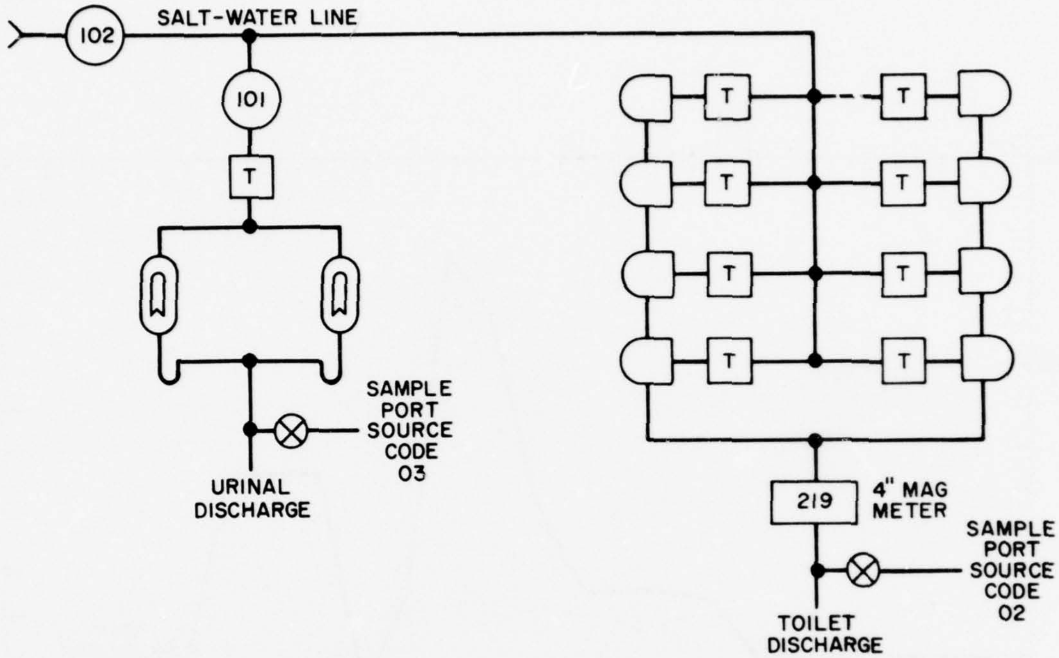


Figure 4
Electromagnetic Flow-Through Meter

Item (a) - Salt-Water System



Item (b) - Potable-Water System

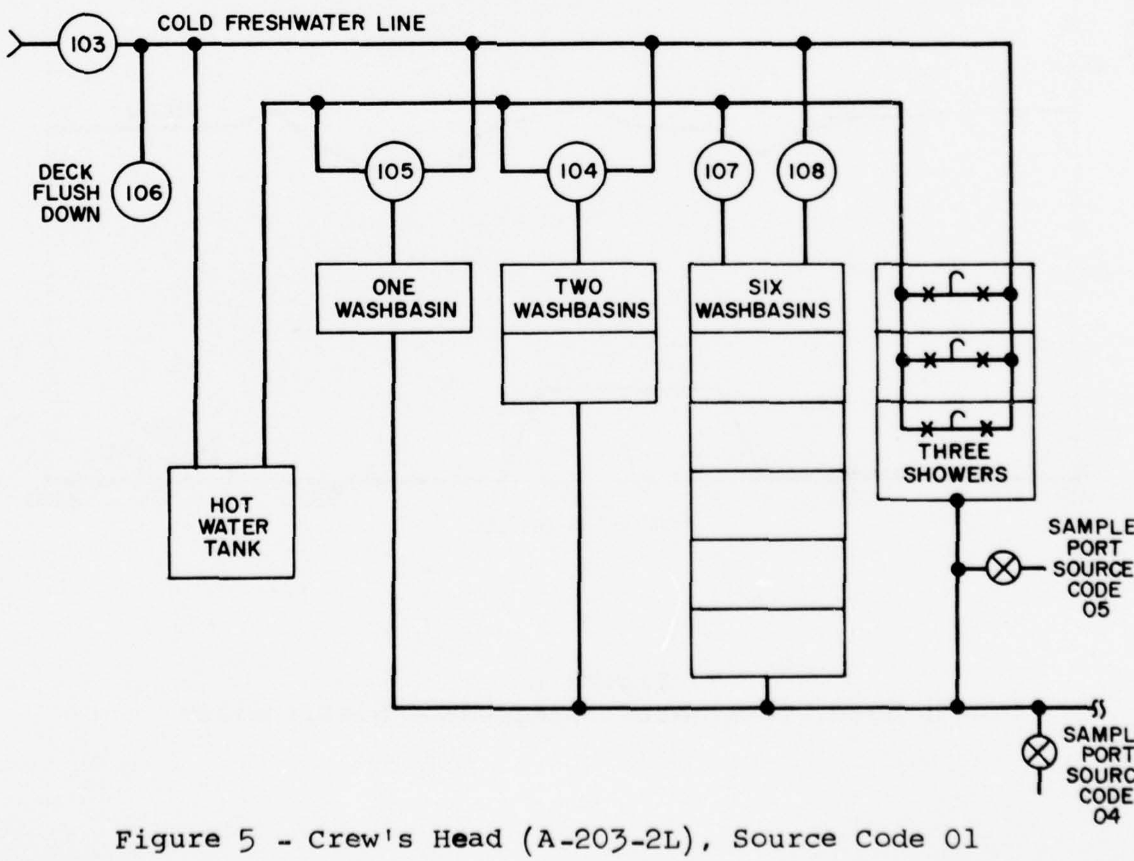


Figure 5 - Crew's Head (A-203-2L), Source Code 01

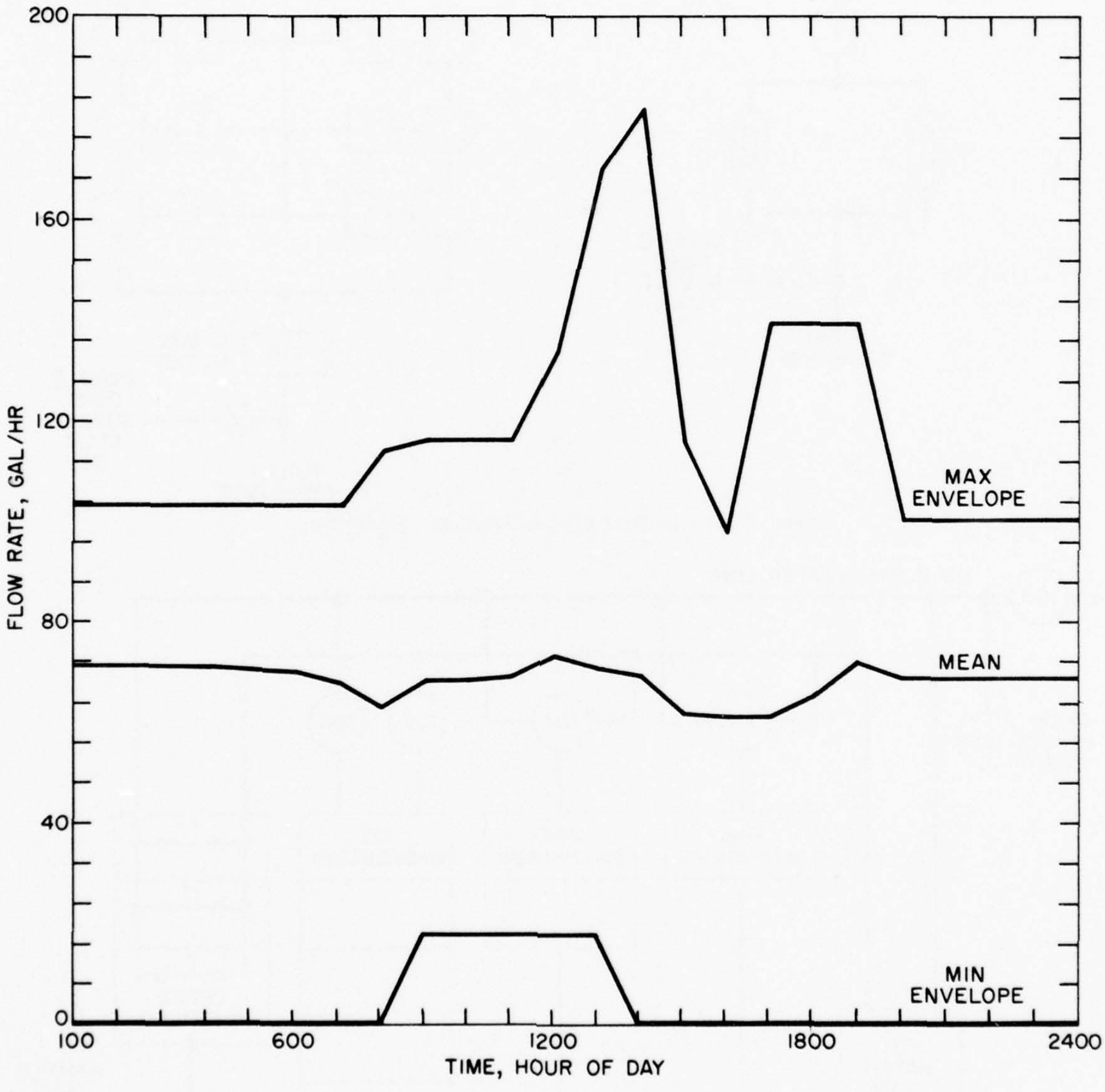


Figure 6
Crew's Head, Total Water Usage-Rate Distribution

Item (a) - Galley

Item (b) - Bake Shop

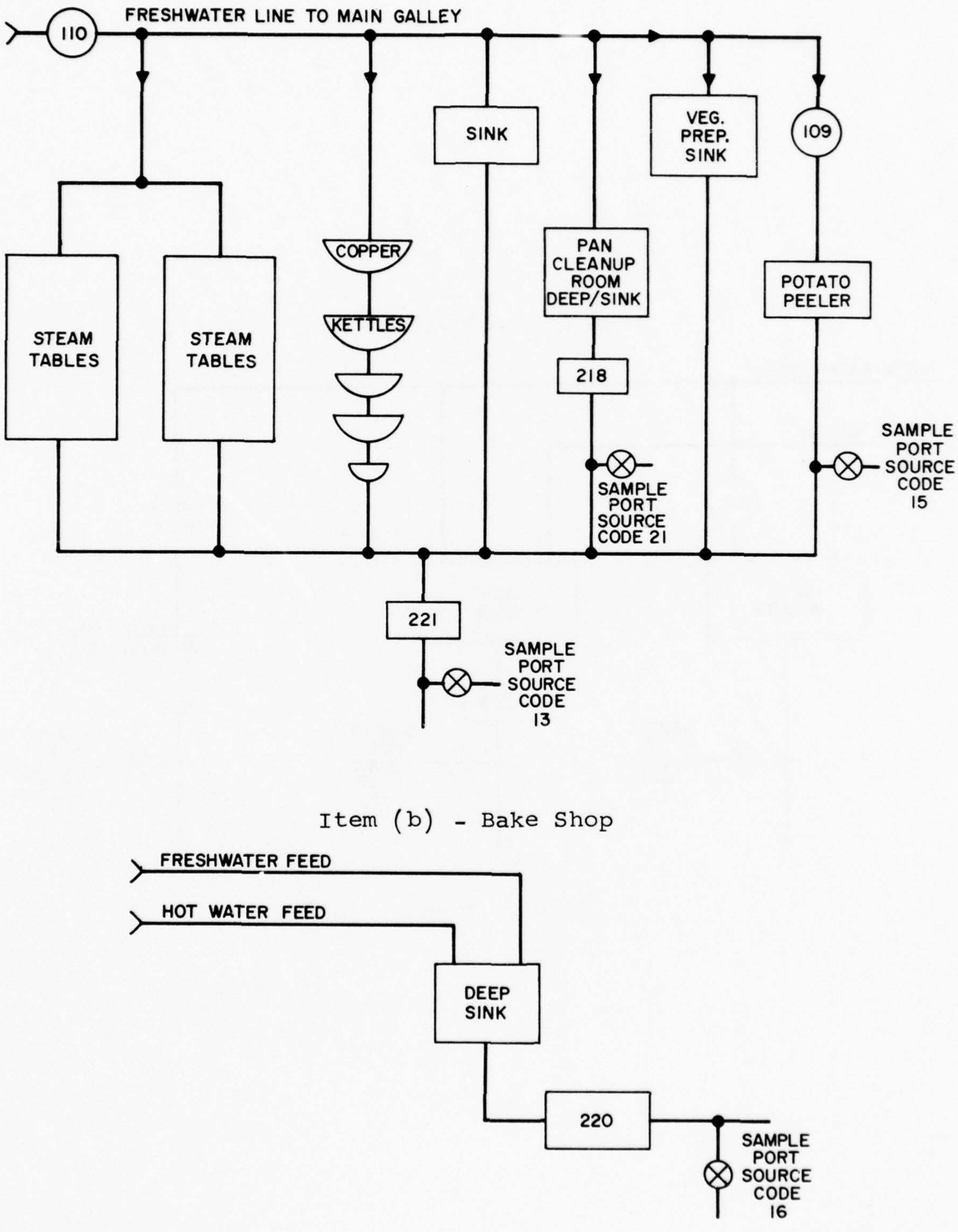


Figure 7
Crew's Food Preparation (A-207-L), Source Code 10

Item (c) - Scullery

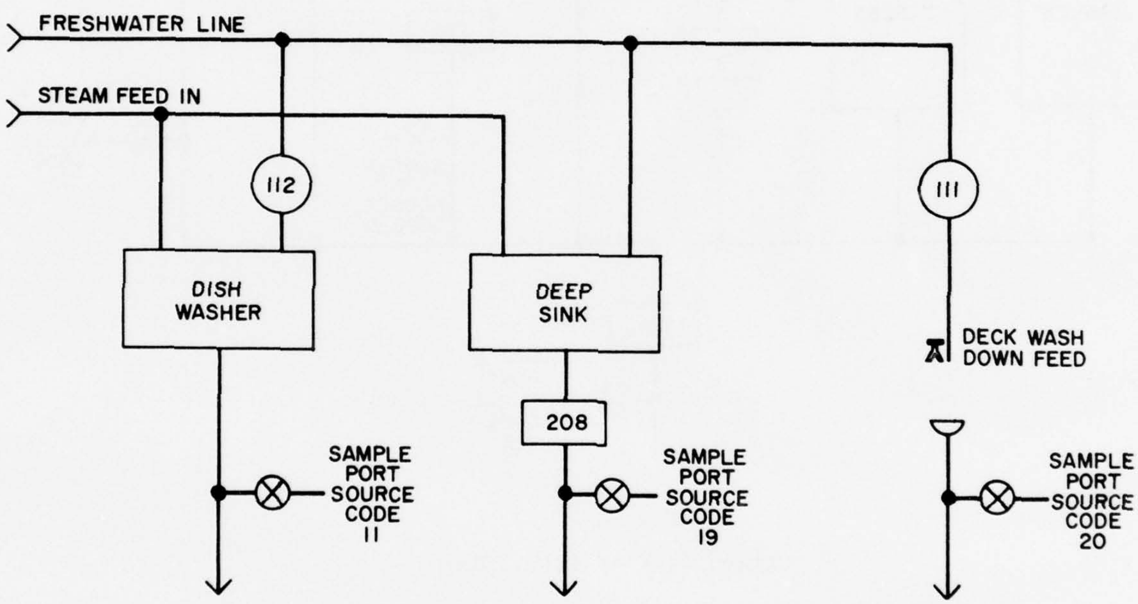


Figure 7 (Cont)

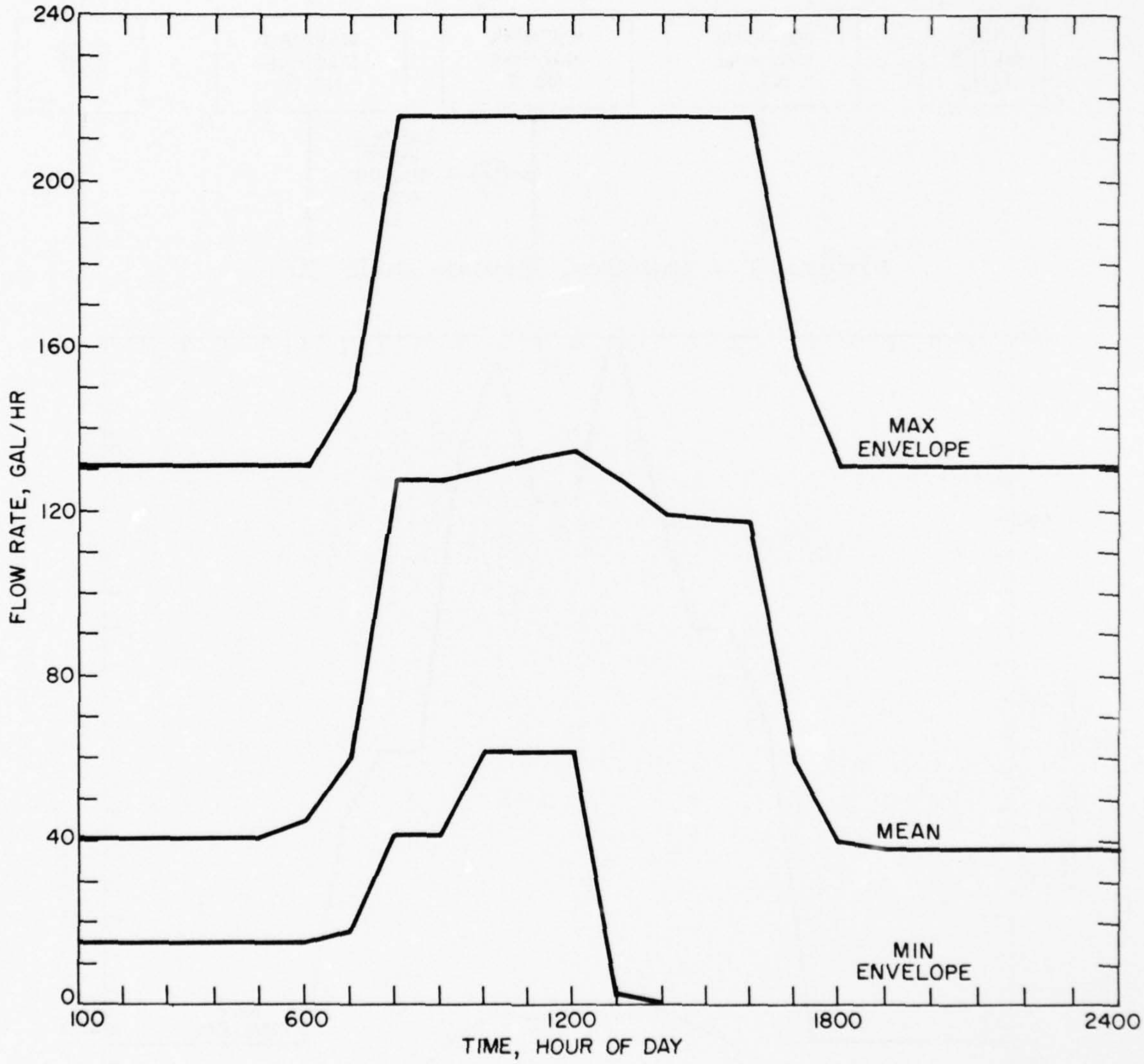


Figure 8
Crew's Food Preparation, Total Water Usage-Rate Distribution

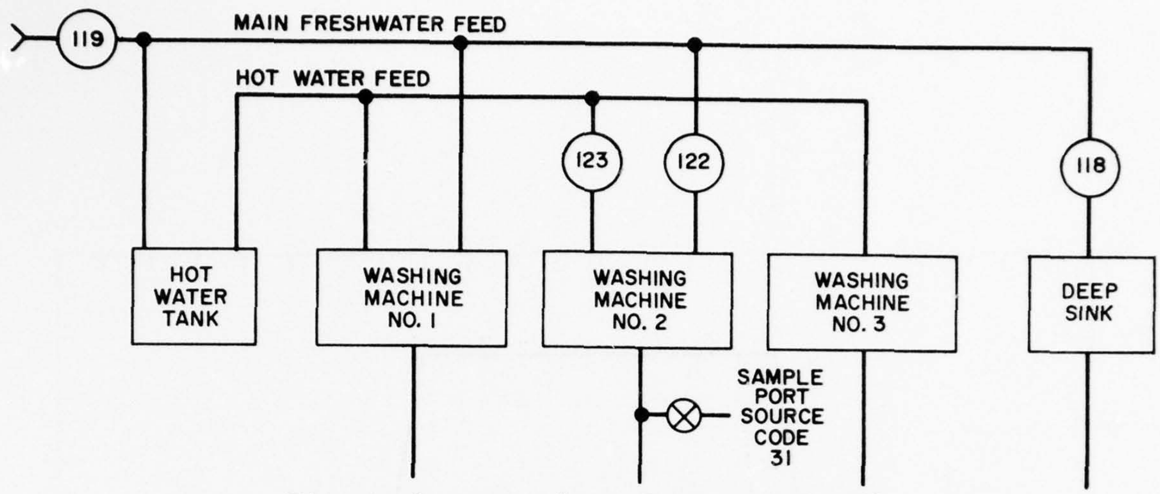


Figure 9 - Laundry, Source Code 30

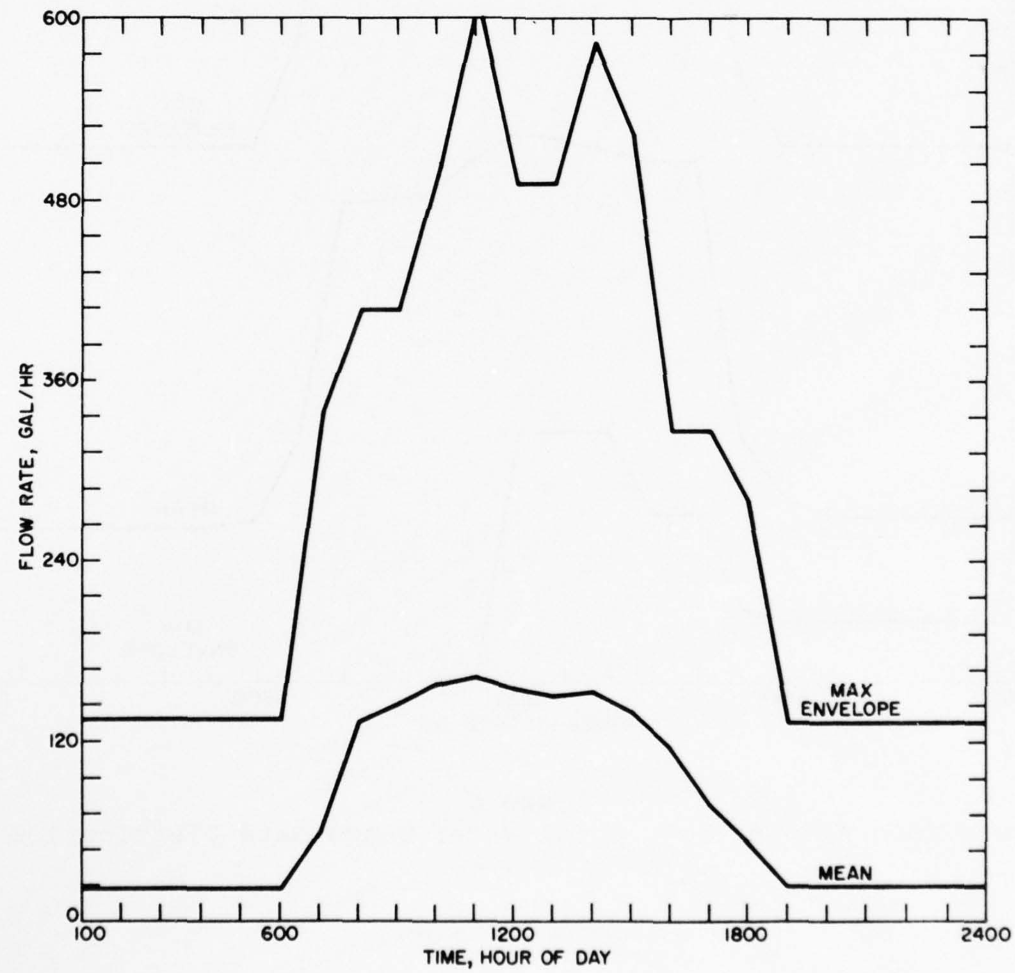


Figure 10
Laundry, Total Flow-Rate Distribution

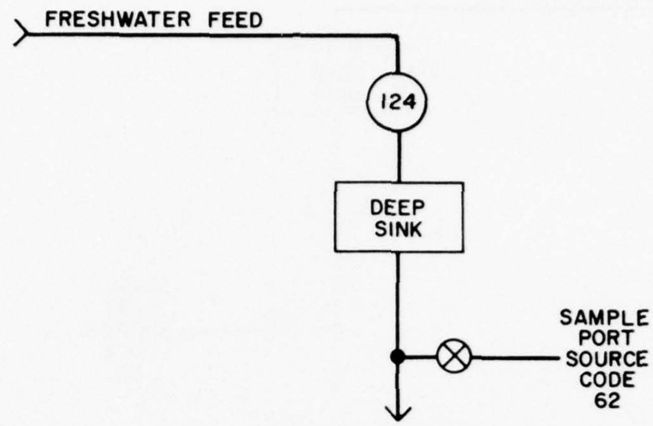


Figure 11 - Industrial Shops, Pipe Shop

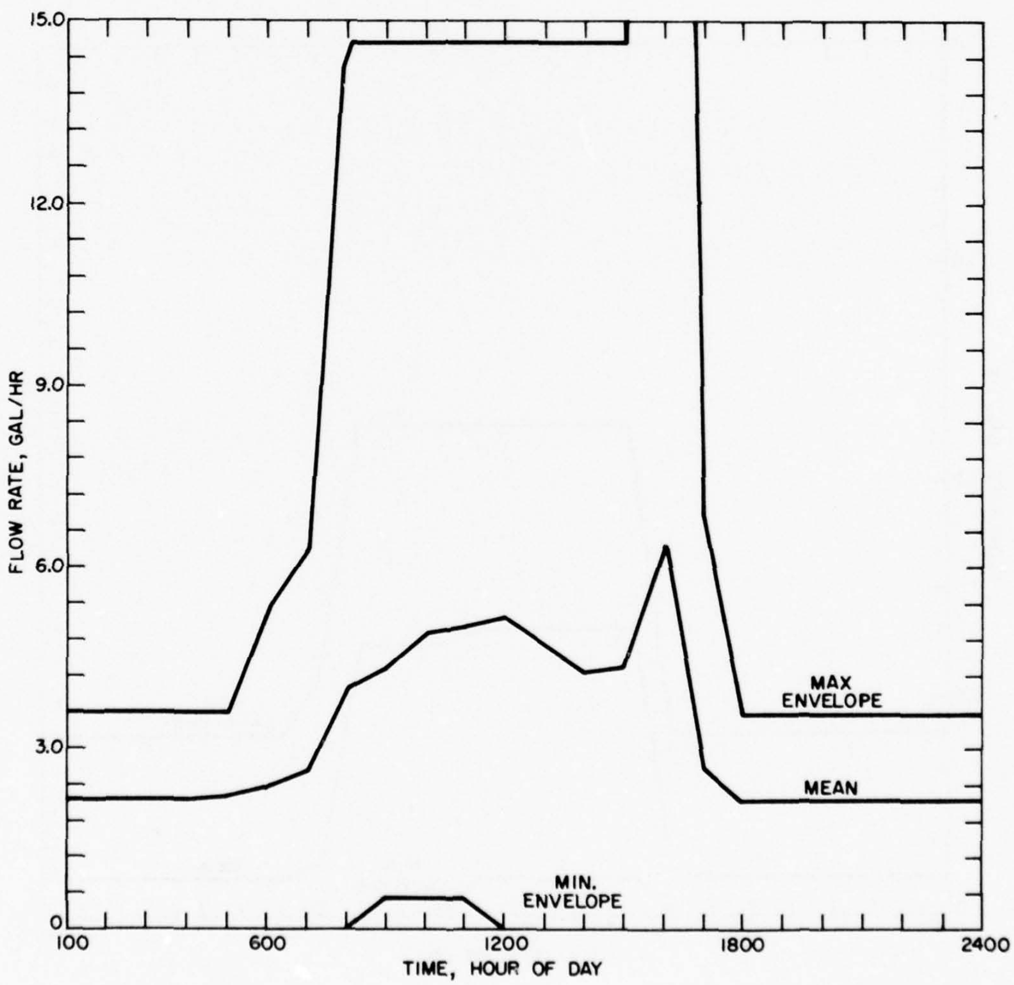


Figure 12
Pipe Shop, Total Flow-Rate Distribution

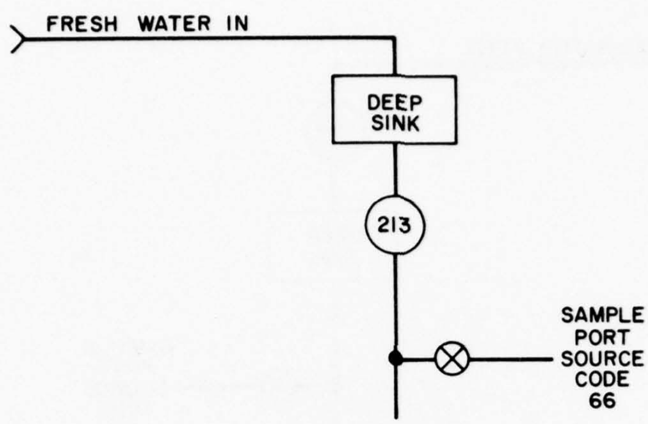


Figure 13
Industrial Shops, Print Shop

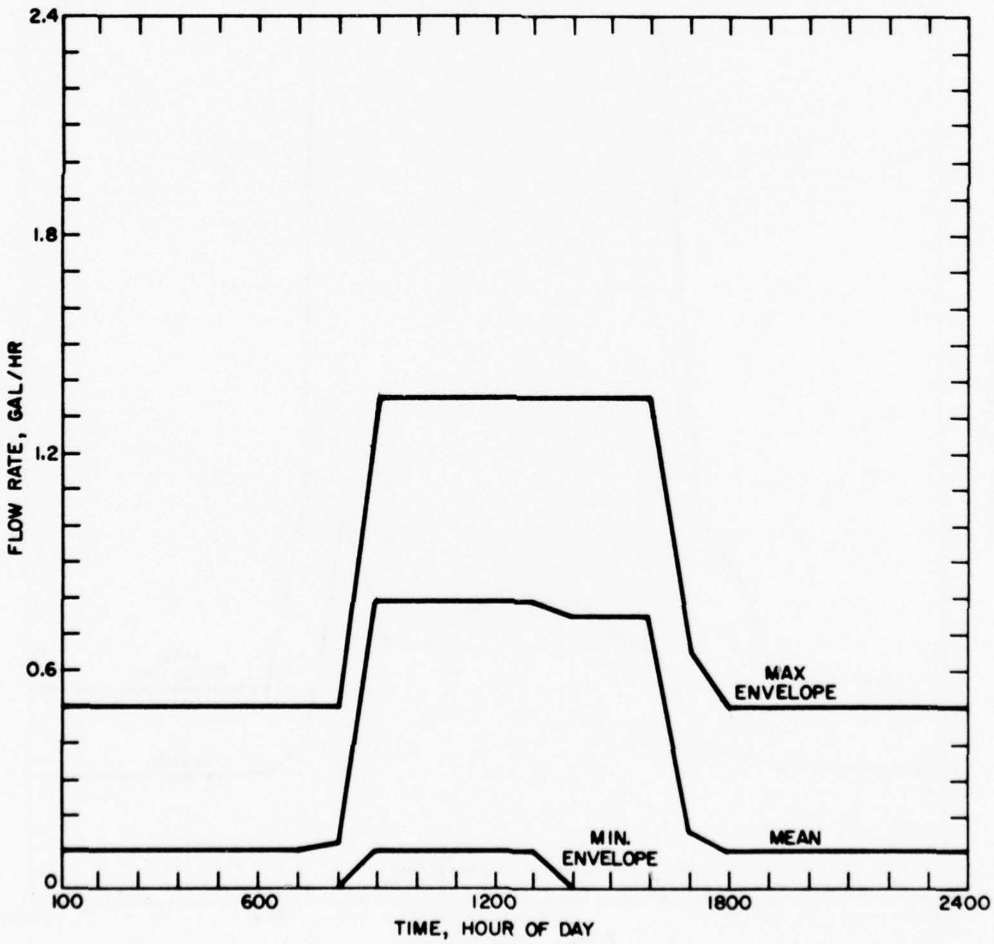


Figure 14
Print Shop, Total Flow-Rate Distribution

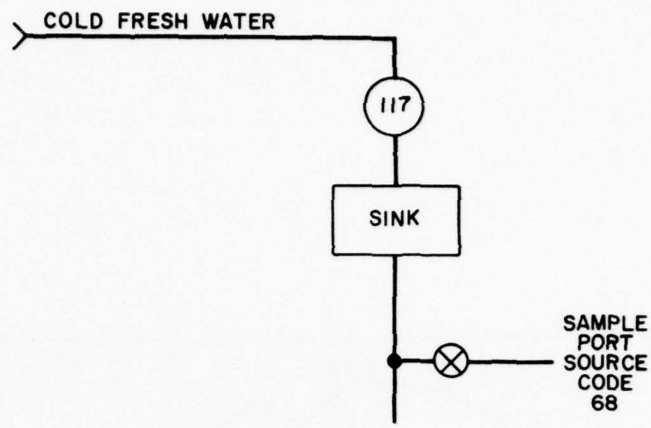


Figure 15
Industrial Shops, Torpedo Repair Shop

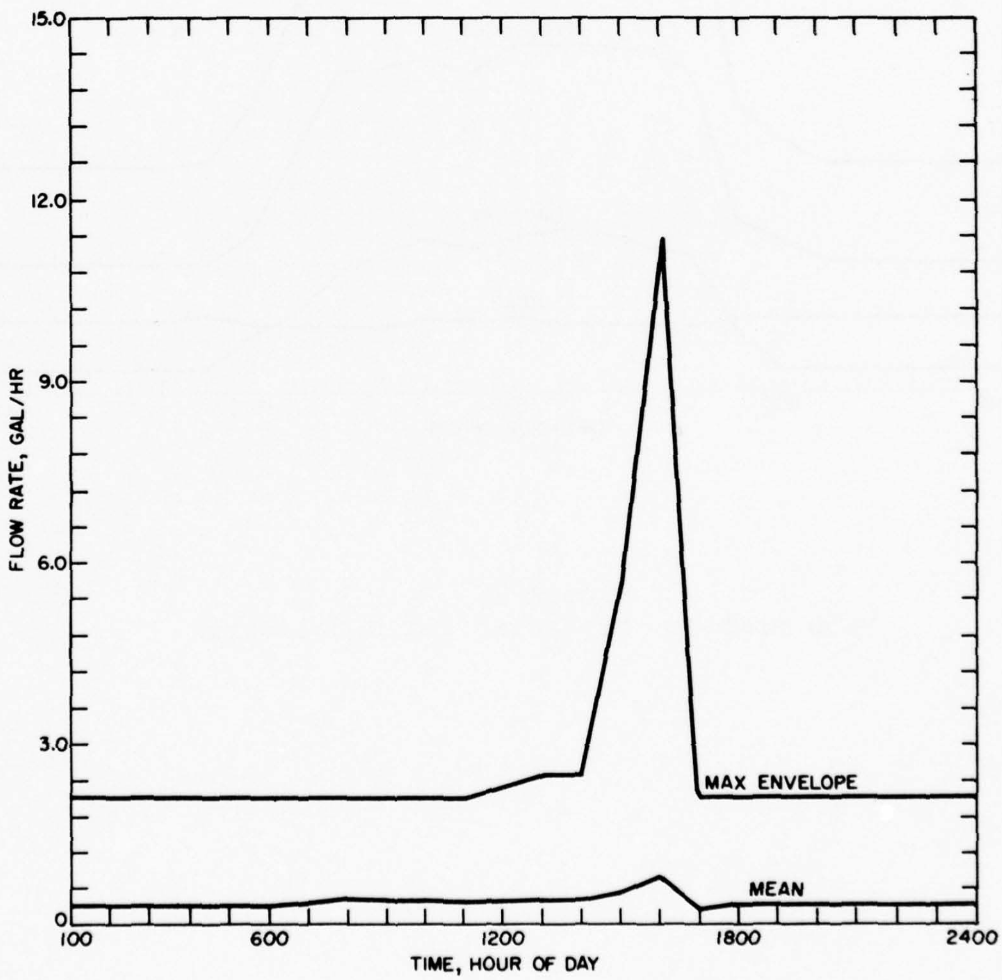


Figure 16
Torpedo Repair Shop, Total Water Flow-Rate Distribution

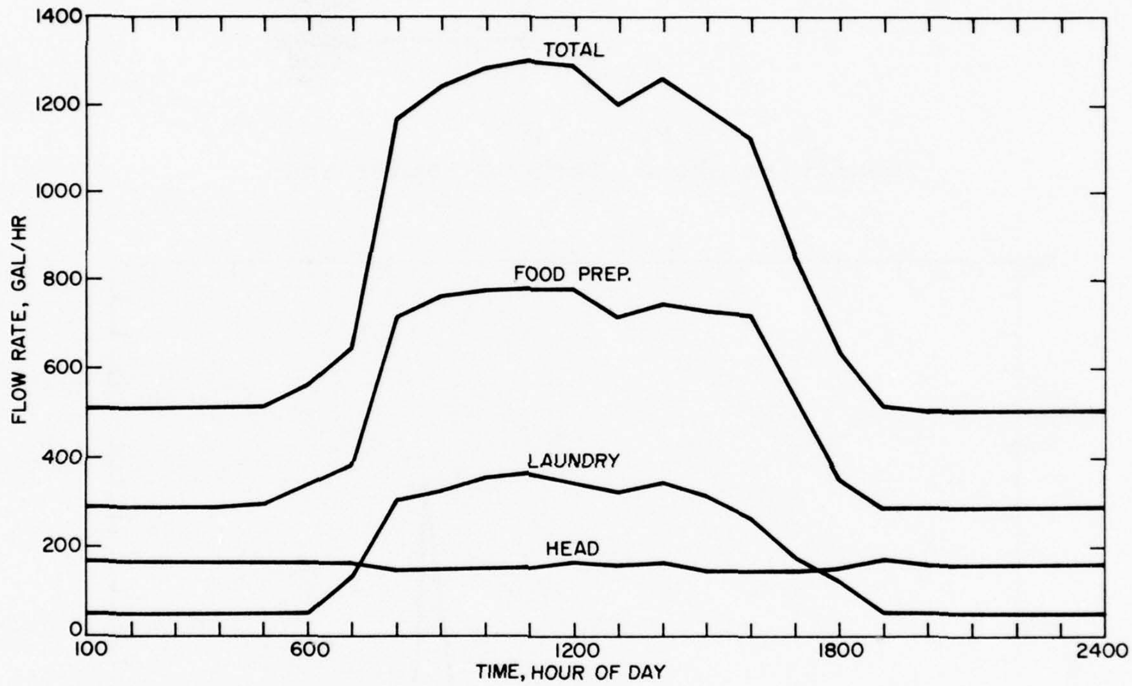


Figure 17
Flow Profile, Projected for Total Ship

APPENDIX A
PRELIMINARY DATA ANALYSIS ON USS SIERRA (AD 18) HYDRAULIC FLOW
NONOILY LIQUID WASTE CHARACTERIZATION

by
Wolfgang Hoffmann
Code 1863

1. GENERAL

Hydraulic data have been provided for the nonoily liquid waste flows deriving from various sources of pollutants measured aboard the USS SIERRA (AD 18) for the period 16 May through 9 June 1972.

Table 4 of the text lists the meters (by number) which were monitored, the source code, and the description of the flow passing through each particular meter. The source codes are numeric identifiers used to correlate the flow data with the concentration data (also collected, but reported separately) and are described in table 1-A.

TABLE 1-A
SOURCE CODE DESCRIPTION

Source	Source Code
Head	
Miscellaneous	01
Commode discharge	02
Urinal discharge	03
Washbasins drains	04
Showers drains	05
Food Preparation	
Miscellaneous	10
Dishwasher drain	11
Galley main drain	13
Potato peeler drain	15
Bake shop sink drain	16
Scullery sink discharge	19
Scullery main drain	20
Pot and pan room sink drain	21
Laundry, main drain	30
Shops	
Pipe shop sink drain	62
Print shop drain	66

Meters in the 100 series are of the positive-displacement, nutating-disk type in the water feedlines to the sources. Those in the 200 series are electromagnetic meters in the discharge fixtures leading from the sources.

The data provided were analyzed to obtain meter totals and averages, described in section 3. Additional computations were performed to obtain gallons/day for each source and the expected gallons/capita/day described in sections 4 and 5, respectively. Flow profiles of monitored sources were also plotted (by computer) in gallons/hour (gal/hr) versus time (in hours) over selected 24-hour periods; an example is shown in section 6.

2. RAW DATA DESCRIPTION

The raw data were transmitted to code 1863 via code 286 (memo file: 2869-501 of 19 March 1973) in a prescribed format. Meter readings were taken by survey personnel several times a day over the survey period and recorded on special format sheets. The data were keypunched and stored on the CDC 6700 computer. The raw data are presented in the following manner:

Source Code

Meter Number

Date of Reading

Time of Reading .

The notation "P" next to any meter reading indicates a possible problem with the meter which made the reading inaccurate.

3. COMPUTATION PROCEDURES

The raw data were used in a computer program for the following calculations on each meter:

(a) Elapsed time between reading, hr.

(b) Gallons passing through meter since last reading.

(c) Gal/hr in each elapsed time interval.

(d) Gallons passing through meter for a 24-hour period.

(e) The average gal/hr over each 24-hour period.

(f) Total number of hours of flow passing through meter (sum of (a)).

(g) Total gallons passing through meter for the total survey period (sum of (b)).

(h) The average gal/hr for the whole survey period ((g) divided by (b)) for each meter.

(i) The average gal/D for the whole survey period for each meter((h) times 24).

The results of these computations are presented. Since the 24-hour period was considered to be from 0000 to 2400 hours of each day, and initial and final meter readings were not taken at those times, the flow calculated in (b) above was taken to be that fraction of the flow proportional to the elapsed time before and after the 2400 time period. In other words, if a meter reading was taken at 1600 on day 1 and at 0800 on day 2, the total flow between ratings was divided by two and assigned to each respective day.

In the case where one or more complete 24-hour periods appeared between meter readings, the flow was proportionally calculated in a similar manner as above. If a meter reading was taken at 1600 on day 1, and the next meter reading was taken at 0800 on day 3, the proportional parts were assigned to each of days 1, 2, and 3.

As mentioned in the introduction, the notation "P" in the raw data indicates either a meter problem or an incorrect reading of the meter. Instructions accompanying the raw data transmission to code 1863 stated that any "P" notations with the meter reading should be excluded from the computation. However, for reasons mentioned in section 4, this was not done.

The computations described in this section are the initial calculations performed on the raw data to obtain summarized hydraulic flow data which will eventually be combined with concentration data to obtain mass emission factors. Additional computations were performed on the data to obtain the gal/D for each source (described in section 4) and the gal/C/D for specific areas (described in section 5).

4. HYDRAULIC FLOW BY SOURCE

In order to facilitate the computation of flow by source, the accompanying table 2-A summarizes the gal/D and gal/hr for each meter total in the "P" corrected and "P" uncorrected versions. The computations to be performed on the data of table 2-A are described in table 5 of the text. Table 3-A presents the results of the data manipulations suggested in table 5 in the text.

TABLE 2-A
USS SIERRA (AD 18) SUMMARY OF METER TOTALS

Meter No.	Source Code	"P" Uncorrected		"P" Corrected	
		Gal/Hr	Gal/D	Gal/Hr	Gal/D
101	03	3.0	70.9	3.0	70.9
102	01	22.6	543.5	20.6	494.8*
103	01	52.3	1256.2	52.3	1256.2
104	04	2.7	64.3	2.7	64.3
105	04	1.7	39.7	1.7	39.7
106	06	1.2	28.4	1.2	28.4
107	04	4.5	107.8	4.5	107.8
108	04	5.8	139.7	5.8	139.7
109	15	1.6	39.4	1.6	39.4
110	10	105.8	2538.9	105.8	2538.9
111	19	39.1	938.3	39.1	938.3
112	11	39.0	935.6	39.0	935.6
113	66	0.4	9.5	0.4	9.5
117	68	0.4	9.2	0.4	9.2
118	32	0.7	16.5	0.7	16.5
119	30	75.5	1811.2	75.5	1811.2
122	31	21.9	525.8	21.9	525.8
123	31	10.2	245.2	10.2	245.2
124	62	3.3	80.0	3.3	80.0
208	19	15.9	382.3	15.9	382.3
218	21	24.9	598.3	24.9	598.3
219	02	18.9	454.2	22.4	537.0*
220	16	68.7	1648.3	6.3	152.0*
221	13	95.8	2300.4	106.8	2563.1*

*Indicates meters with "P".

TABLE 3-A
USS SIERRA FLOW BY SOURCE, GAL/HR VERSUS GAL/D

Description	Gal/Hr	Gal/D
Crew's Head		
Salt water total flow	22.6	543.5
Salt water to commodes	19.6	472.6
Salt water to urinals	3.0	70.9
Potable total flow	52.3	1256.2
Potable water to washbasins	14.7	351.5
Potable water to showers	36.4	876.3
Potable water to head, deep sink, deck wash	1.2	28.4
Total water use in head (salt and potable)	74.9	1799.7
Crew's Food Preparation		
Potable water total	258.5	6204.0
Potable water, galley (dishwasher)	139.6	3350.4
Potable water, scullery and clean-up*	79.9	1918.9
Potable water, dishwasher	39.0	935.6
Laundry		
Potable water, total use	75.5	1811.2
Potable water, one washing machine	32.1	771.0
Potable water, deep sink	0.7	16.5
Shops		
Pipe shop, potable water	3.3	80.0
Print shop, potable water	0.4	9.5
Torpedo repair shop, potable water	0.4	9.2

*Less dishwasher.

Procedures a through c under Crew's Head in table 5 of the text include computations performed on meters with possible problems. In doing the comparisons to other meters as suggested in these procedures, the "P" uncorrected always compared more favorably than the "P" corrected. It was therefore decided to use the "P" uncorrected column of table 2-A to perform these calculations.

5. PER CAPITA FLOW BY AREA

The next step in the computation was to obtain the gal/C/D flow for each source. However, the per capita flow could only be calculated for the total flow in each area (head, food preparation, and laundry) because of the difficulty in counting the number of individuals using specific sources. The average number of individuals using each area is the following: head - 85, food preparation - 431, and laundry - 413.

Another difficulty was the assignment of a meaningful flow characteristic in the shop areas. Shop area flow is not really meaningful on a per capita basis. This difficulty is yet to be resolved.

Table 4-A presents the gal/C/D flow for the head, food preparation, and laundry areas. For shop areas, both the gal/D flow and the gal/C/D was included as being informative. Volume II contains all of the raw flow data, the results of the calculations performed on that data, and displays of the source flow profiles. Table 5-A is an example of the raw flow data and calculations.

TABLE 4-A
USS SIERRA FLOW BY AREA

Description	Gal/C/D
Crew's head	
Total salt-water usage	6.4
Total potable-water usage	14.8
Total usage (salt and potable)	21.2 (20.8)*
Crew's galley, total potable-water usage	14.4
Shops	
Pipe shop (6 men)	80.0 (13.3)
Print shop (8 men)	9.5 (1.2)
Torpedo repair shop (20 men)	9.2 (0.46)
Laundry, total potable-water usage	4.4
Total gal/C/D (head and galley and laundry) =	40.5

*Without deep sink.

6. SOURCE FLOW PROFILES

Volume II contains a complete set of graphs of flow rate (gal/hr) versus time (hours of day) for all monitored waste sources; an example is provided herein as figure 1-A.

TABLE 5-A

USS SIERRA (AD 18)
EXAMPLE OF RAW FLOW DATA AND CALCULATIONS

TABLE 5-A (CONT)

SOURCE	METER	YR	MTH	DY	TIME START	TIME END	HRS	FLOW	AV. GALS/HR	HRS/DAY	GALS/DAY	AV.GPH/DAY
1	102	72	5	16	800.	1600.	8.0	85.0	10.6			
1	102	72	5	16	1600.	1900.	3.0	201.0	67.0			
1	102	72	5	16	1900.	2400.	5.0	79.3	15.9	16.0	365.3	22.8
1	102	72	5	17	0.	1000.	10.0	158.7	15.9			
1	102	72	5	17	1000.	1030.	.5	4.0	8.0			
1	102	72	5	17	1030.	1130.	1.0	24.0	24.0			
1	102	72	5	17	1130.	1230.	1.0	33.0	33.0			
1	102	72	5	17	1230.	1330.	1.0	5.0	5.0			
1	102	72	5	17	1330.	1430.	1.0	6.0	6.0			
1	102	72	5	17	1430.	1530.	1.0	129.0	129.0			
1	102	72	5	17	1530.	1600.	.5	26.0	52.0			
1	102	72	5	17	1600.	2400.	8.0	110.6	13.8	24.0	496.3	20.7
1	102	72	5	18	0.	645.	6.7	93.4	13.8			
1	102	72	5	18	645.	815.	1.5	60.0	40.0			
1	102	72	5	18	815.	1030.	2.3	12.0	5.3			
1	102	72	5	18	1030.	1200.	1.5	42.0	28.0			
1	102	72	5	18	1200.	1330.	1.5	19.0	12.7			
1	102	72	5	18	1330.	1500.	1.5	29.0	19.3			
1	102	72	5	18	1500.	1615.	1.2	30.0	24.0			
1	102	72	5	18	1615.	2400.	7.8	1076.4	138.9	24.0	1361.8	56.7
1	102	72	5	19	0.	830.	8.5	1180.6	138.9			
METER TROUBLE												
1	102	72	5	19	830.	1400.	5.5	204.0	37.1			
1	102	72	5	19	1400.	2400.	10.0	16.4	1.6	24.0	1401.0	58.4
1	102	72	5	20	0.	815.	8.2	13.6	1.6			
1	102	72	5	20	815.	2400.	15.7	296.9	18.9	24.0	310.5	12.9
1	102	72	5	21	0.	745.	7.7	146.1	18.9			
1	102	72	5	21	745.	1700.	9.2	226.0	24.4			
1	102	72	5	21	1700.	2400.	7.0	64.6	9.2	24.0	436.7	18.2
1	102	72	5	22	0.	830.	8.5	78.4	9.2			
1	102	72	5	22	830.	1630.	8.0	203.0	25.4			
1	102	72	5	22	1630.	2400.	7.5	132.5	17.7	24.0	413.9	17.2
1	102	72	5	23	0.	730.	7.5	132.5	17.7			
1	102	72	5	23	730.	1600.	8.5	419.0	49.3			
1	102	72	5	23	1600.	2400.	8.0	140.0	17.5	24.0	691.5	28.8
1	102	72	5	24	0.	800.	8.0	140.0	17.5			
1	102	72	5	24	800.	1530.	7.5	311.0	41.5			
1	102	72	5	24	1530.	2400.	8.5	133.9	15.7	24.0	584.9	24.4
1	102	72	5	25	0.	730.	7.5	118.1	15.7			
1	102	72	5	25	730.	1530.	8.0	241.0	30.1			
1	102	72	5	25	1530.	2400.	8.5	191.2	22.5	24.0	550.3	22.9
1	102	72	5	26	0.	1600.	16.0	359.8	22.5			
1	102	72	5	26	1600.	2400.	8.0	98.3	12.3	24.0	458.1	19.1
1	102	72	5	27	0.	2400.	48.0	589.7	12.3	48.0	589.7	12.3
			TO THE									
1	102	72	5	29	0.	1045.	10.7	132.1	12.3			
1	102	72	5	29	1045.	1400.	3.3	435.0	133.8			

TABLE 5-A (CONT)

SOURCE	METER	YR	MTH	DY	TIME START	TIME END	HRS	FLOW	AV. GALS/HR	HRS/DAY	GALS/DAY	AV.GPH/DAY
1	102	72	5	29	1400.	1700.	3.0	40.0	13.3			
1	102	72	5	29	1700.	2400.	7.0	115.8	16.5	24.0	722.8	30.1
1	102	72	5	30	0.	640.	6.7	110.2	16.5			
1	102	72	5	30	640.	1800.	11.3	159.0	14.0			
1	102	72	5	30	1800.	2400.	6.0	92.4	15.4	24.0	361.6	15.1
1	102	72	5	31	0.	640.	6.7	102.6	15.4			
1	102	72	5	31	640.	1800.	11.3	340.0	30.0			
1	102	72	5	31	1800.	2400.	6.0	41.5	6.9	24.0	484.2	20.2
1	102	72	5	1	0.	700.	7.0	48.5	6.9			
1	102	72	6	1	700.	1745.	10.7	283.0	26.3			
1	102	72	6	1	1745.	2400.	6.3	126.0	20.2	24.0	457.4	19.1
1	102	72	6	2	0.	630.	6.5	131.0	20.2			
1	102	72	6	2	630.	1745.	11.2	258.0	22.9			
1	102	72	6	2	1745.	2400.	6.3	69.2	11.1	24.0	458.2	19.1
1	102	72	6	3	0.	635.	6.6	72.8	11.1			
1	102	72	6	3	635.	1750.	11.2	125.0	11.1			
1	102	72	6	3	1750.	2400.	6.2	36.5	5.9	24.0	234.4	9.8
1	102	72	6	4	0.	630.	6.5	38.5	5.9			
1	102	72	6	4	630.	1750.	11.3	60.0	5.3			
1	102	72	6	4	1750.	2400.	6.2	107.0	17.3	24.0	205.4	8.6
1	102	72	6	5	0.	430.	4.5	78.0	17.3			
1	102	72	6	5	430.	1815.	13.7	397.0	28.9			
1	102	72	6	5	1815.	2400.	5.8	88.2	15.3	24.0	563.3	23.5
1	102	72	6	6	0.	630.	6.5	99.8	15.3			
1	102	72	6	6	630.	1735.	11.1	357.0	32.2			
1	102	72	6	6	1735.	2400.	6.4	105.8	16.5	24.0	562.6	23.4
1	102	72	6	7	0.	630.	6.5	107.2	16.5			
1	102	72	6	7	630.	1745.	11.2	269.0	23.9			
1	102	72	6	7	1745.	2400.	6.3	113.2	18.1	24.0	489.4	20.4
1	102	72	6	8	0.	630.	6.5	117.8	18.1			
1	102	72	6	8	630.	1745.	11.2	425.0	37.8			
1	102	72	6	8	1745.	2400.	6.3	85.8	13.7	24.0	628.5	26.2
1	102	72	6	9	0.	630.	6.5	89.2	13.7			
1	102	72	6	9	630.	1220.	5.8	225.0	38.6			
										12.3	314.2	25.5

METER TOTALS

TOTAL HOURS= 580.3
TOTAL GALS = 13142.0
AV.GALS/DAY= 543.5 AV.GALS/HR = 22.6

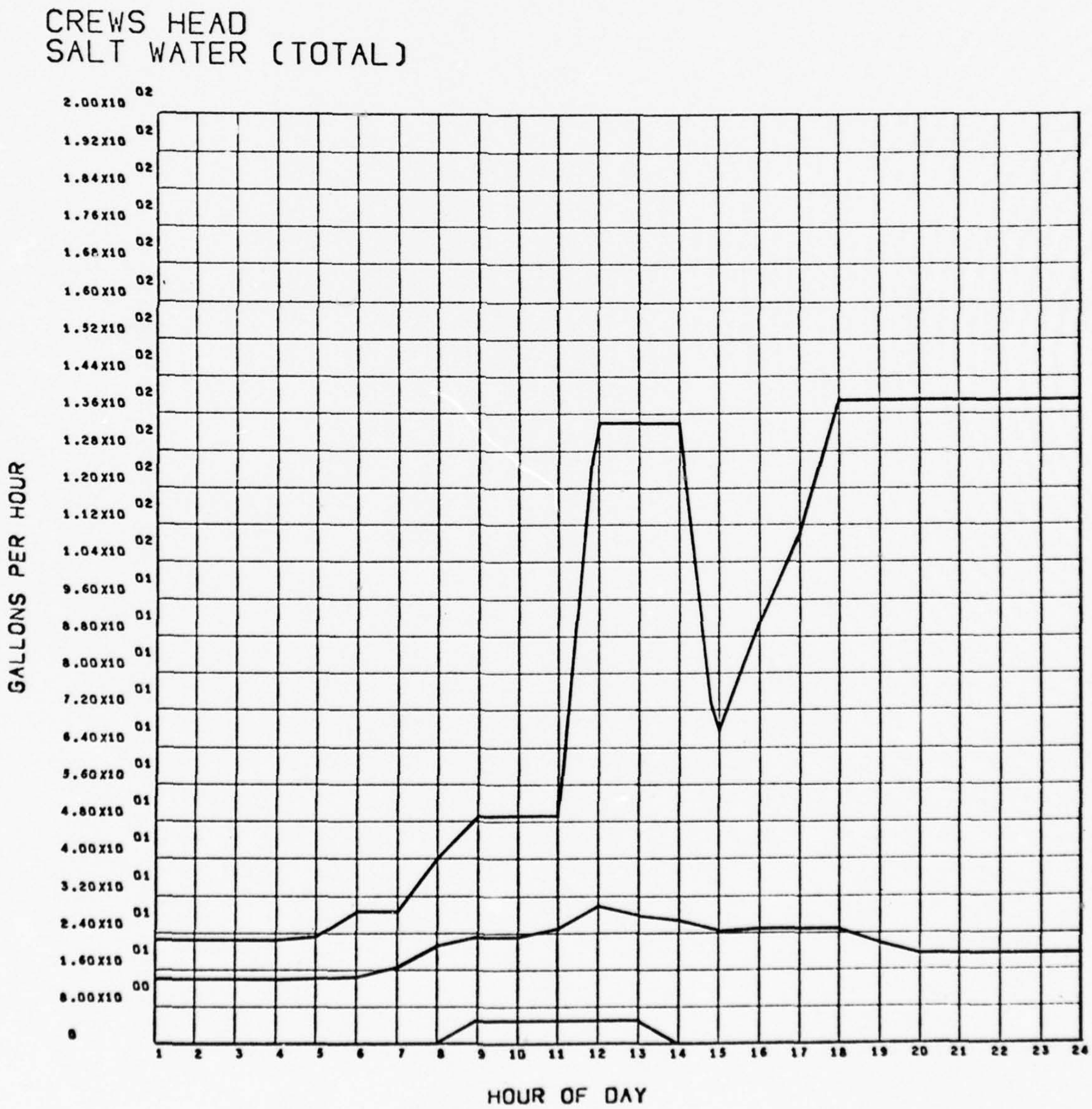


Figure 1-A - Example of Source Flow Profile

APPENDIX B

ANALYSIS OF LIQUID WASTE CONSTITUENTS GENERATED ABOARD USS SIERRA (AD 18)

by
Michael Lamatrice
Code 1863

1. INTRODUCTION

Shipboard liquid waste consists of all solutions which are eliminated from the ship through the piping system. Oily fluids such as those generated in bilges are excluded from this definition since they are treated in a separate study.

Qualitative samples were obtained at each source by tapping discharge lines aboard the ships. The sampling was accomplished in two ways - grab sampling and composite sampling. The collected liquid was chemically analyzed to obtain the concentrations of up to 53 substances.

The data were then analyzed mathematically to provide guidance for future sampling and also to provide estimates of the per-man generation of liquid waste.

2. INPUT DATA DESCRIPTION

The spaces which were monitored are referred to as sources. The sources have been numbered for bookkeeping purposes. This numbering has been made versatile enough to include all types of shipboard spaces in logical groupings. Table 1-B illustrates the source numbering.

The individual constituents of the fluids are referred to as categories. The results of the chemical analysis were entered on a data sheet, figure 1 of the text. The format of the data sheet facilitates computerization of the data, and eliminates most of the error arising from the previously used procedure of transcribing and retranscribing the data. The format allows for decimal numbers (F-Format) containing a maximum of nine significant digits. Large numbers can be entered using scientific notation (E-Format, right adjusted). If no test was performed for a particular pollutant, the appropriate field is left blank. Any pollutant having a concentration less than the established detection limit is noted by entering a -2.0 in the field. For those pollutants having a value greater than the measurable limit, a -3.0 is entered in its field.

For bacteriological data:

- Total coliform: -3.0 usually implies $>2\times10^5$, occasionally (rarely) $>10^4$; -2.0 usually implies <10, frequently <20 or <100.

- Fecal coliform: -3.0 usually implies $>2\times10^4$, occasionally $>2\times10^5$; -2.0 usually implies <10, frequently <20 or <100.

Table 7 of the text describes the lower limits at which the categories could normally be detected. Concentration data are presented in volume II; an example is provided in table 2-B. Tables 2-B through 6-B display examples of analyzed data for appropriate sources, categories, and units. Tables 7-B and 8-B are examples of further analyses of data and computed mass emission factors. Complete information is provided in volume II.

3. METHODOLOGY

Several questions arise as to the variation of pollutant concentrations due to changes in factors such as time of day, duration of sampling period, sampling method, and whether the ship was in port or at sea. By analyzing the thousands of samples in the data base, some answers to these questions can be obtained.

For observations within the detectable limits, concentrations were tabulated for each source and separated into two groups, e.g., week days, weekends. The sample sizes, their means, and standard deviations were computed for each category in both groups and a comparison of the two groups was made, category-by-category. After each source was tested in this way, all sources were grouped together, and the procedure repeated for each category.

The results of the analysis were coded to arrange the computer output more neatly, and a key was formulated explaining the analysis code. Tables 2-B through 8-B illustrate the results of the statistical analysis.

In order to make a valid comparison of the averages in the groupings, a t-test must be applied to the null hypothesis, H_O: $\overline{x}_1 = \overline{x}_2$. The t-test is used because if the two samples belong to the same population, i.e., $\overline{x}_1 = \overline{x}_2$, then the sample means will be normally distributed about the population mean, even if the distribution within the samples is not normal. Likewise, since the population variance, σ^2, is not known, the t-statistic uses an estimate, s_C^2, of σ^2 by pooling the sample variances, s_1^2 and s_2^2, of both samples and dividing by the total number of degrees of freedom. Thus,

$$s_c^2 = \frac{s_1^2 (n_1 - 1) + s_2^2 (n_2 - 1)}{n_1 + n_2 - 2} \quad .$$

The standard deviations of the two means are $s_c/\sqrt{n_1}$ and $s_c/\sqrt{n_2}$, respectively, and the standard deviation of the difference of means is

$$s_d = \sqrt{\frac{s_c^2}{n_1} + \frac{s_c^2}{n_2}} = s_c \sqrt{\frac{n_1 + n_2}{n_1 n_2}} \quad .$$

The significance of the difference is measured by the ratio of the absolute value of the difference to its standard deviation, and is denoted by

$$t = \frac{|\overline{x}_1 - \overline{x}_2|}{s_d} \quad ,$$

i.e.,

$$t = \frac{|\overline{x}_1 - \overline{x}_2|}{\sqrt{\frac{s_1^2 (n_1 - 1) + s_2^2 (n_2 - 1)}{n_1 + n_2 - 2} \left(\frac{n_1 + n_2}{n_1 n_2}\right)}} \quad ,$$

where the number of degrees of freedom is the number of observation minus two (which were used in determining the sample means).

The probability of $|\overline{x}_1 - \overline{x}_2|$ exceeding ts_d, if drawn by chance from the same population, represents the odds against the null hypothesis, and is called the level of significance. The level of significance for all phases of this analysis is set at 0.05, or the 5% level of significance. If the calculated value of t is greater than the tabulated value of t for the particular number of degrees of freedom at the 5% level of significance, the null hypothesis is rejected. The conclusion is that the difference is significant. If the calculated t is not greater than the tabulated t, then the null hypothesis is accepted; it cannot be said whether there is no difference between the means or whether the data are inadequate to establish the difference.

Since the null hypothesis being examined by the t-test assumes that the two samples belong to the same population, the two variance estimates must be consistent with the hypothesis, i.e., the two variances must not be significantly different. This is verified by means of the F-test before the t-test is applied. In performing the F-test (variance-ratio test), a null hypothesis is adopted that the two variances belong to the same population. The F statistic is calculated as

$$F = \frac{s_i^2}{s_j^2} ,$$

where $s_i > s_j$. This condition must be satisfied as the F-test is a one-sided test when the alternative to the null hypothesis is $s_i^2 > s_j^2$. The number of degrees of freedom is $v_1 = n_i - 1$ and $v_2 = n_j - 1$, since, given the value of the variance and $n - 1$ observations, the nth observation is uniquely determined. If the calculated F exceeds the tabulated value this implies that the probability that the difference between the two variances is due to chance alone is smaller than the level of significance. Hence, the null hypothesis is rejected.

Even if the F-test is not passed (null hypothesis rejected), it may still be useful to test the significance of the difference of the two means. This is the case, for example, when measurement errors are due to different causes so that the estimates of variance cannot correctly be pooled. The t-test cannot be applied; hence, a test is used in which the ratio of the standard deviations of the two samples is considered in determining the significance of the difference of the means. The difference, $\overline{x}_1 - \overline{x}_2$, is considered significant if

$$\frac{|\overline{x}_1 - \overline{x}_2|}{\sqrt{s_{x_1}^2 + s_{x_2}^2}} > d ,$$

where

$$d = \text{ARC TAN} \frac{s_{\overline{x}_1}}{s_{\overline{x}_2}} .$$

The number of degrees of freedom are $v_1 = n_1 - 1$ and $v_2 = n_2 - 1$.

After the calculations are completed on the observations within the detection limits, a further stratification of the data is performed. This stratification consists in separating the data into the following partitions:

$P_{j,1}$ = The proportion of observations below the detection limit.

$P_{j,2}$ = The proportion of observations within the detection limits.

$P_{j,3}$ = The proportion of observations outside the measurable limit, where j = 1, 2, denotes the major grouping.

For each of the three partitions, a test is made to determine the significance of the difference between corresponding proportions from both the major groupings; e.g., suppose that the source is the galley kettle drain, the category total coliform count, and the major groupings are input for the at-sea mode. Let $P_{1,1}$ be the proportions observed in port for the partitions, and let $P_{2,1}$ be the proportions observed at sea. Then $P_{1,1}$ is compared to $P_{2,1}$; $P_{1,2}$ is compared to $P_{2,2}$; $P_{1,3}$ is compared to $P_{2,3}$.

Again, the null hypothesis is, H_O: $P_{1,i} = P_{2,i}$. The sampling distribution of differences in proportions is approximately normal with mean and standard deviation given by

$$\mu_{P_1 - P_2} = 0 \text{ and } \sigma_{P_1 - P_2} = \sqrt{pq\left(\frac{n_1 + n_2}{n_1 n_2}\right)} ,$$

where

$$p = \frac{n_1 P_1 + n_2 P_2}{n_1 + n_2}$$

is used as an estimate of the population proportion, and q = 1 - p. P_1 and P_2 will be used as a short form of $P_{1,i}$ and $P_{2,i}$.

By computing the statistic

$$z = \frac{|P_1 - P_2|}{\sigma_{P_1 - P_2}},$$

the differences can be tested as above, but using tables of the normal distribution.

Four categories were handled somewhat differently from the others; these were: total volatile suspended solids, total volatile solids, soluble BOD, soluble COD. In these cases, the percent of each of these categories of their respective total categories, i.e., TSS, TS, BOD, COD, were computed and used throughout the analysis.

The category alkalinity/acidity on the data sheet contains only a single entry. The entry refers to alkalinity if the pH value for the particular sample were greater than 7. If pH is less than 7, the number refers to acidity. These values were sorted by the statistical program and separate analyses were run for alkalinity and acidity.

5. RECOMMENDATION

After a preliminary check of the other ships (O'HARE and SEATTLE) surveyed under this program, it is evident that a firm data base has been established for head, laundry, and galley/scullery areas. For this reason, further sampling of such spaces can be greatly curtailed. However, many types of shops and miscellaneous spaces have not yet been sampled. In order to round out the data base, some selective sampling of these areas, both in port and at sea, should be performed. The results of this sampling will be important in the development of the mass emission factors catalog.

6. FUTURE PLANS

Other tests have been performed aboard the USS O'HARE (DD 889), USS SEATTLE (AOE 3), and the USS INDEPENDENCE (CV 62). The data has been computerized and will be analyzed in a manner similar to that of the SIERRA. Results of the analysis will be published as they are completed. The data may be validated and checked for consistency by comparing similar spaces from each ship.

A more detailed statistical analysis is being planned which will include an overall analysis of variance to determine which factors have a significant effect on the concentrations, and a study of the distributions of the individual categories to obtain confidence intervals for the concentration averages.

TABLE 1-B
POLLUTANT SOURCES

Source Code	Description
	Head (01-09)
01	Miscellaneous
02	Commodes
03	Urinals
04	Washbasins
05	Showers
06	Deep sink
	Food Preparation (10-29)
10	Miscellaneous
11	Dishwasher
12	Galley deep sink
13	Galley main drain
14	Galley kettle
15	Potato peeler
16	Bake shop
17	Vegetable sink
18	Garbage grinder
19	Scullery sink
20	Scullery main drain
21	Pot and pan clean-up room drain
	Laundry (30-39)
30	Main drain
31	Washing machine
32	Deep sink
41	Medical and Dental (40-49), Sick bay
	Laboratories (50-59)
53	Oil shack
54	Oil test lab
	Shops
62	Pipe
63	Shipfitters
65	Battery
66	Print
67	Filter cleaning
	Other (70-99)

TABLE 2-B

EXAMPLE OF SIERRA LIQUID WASTE SORTED LABORATORY DATA

NO.	SOURCE
1	HEAD (MISCELLANEOUS)
2	COMMODES
3	URINALS
4	WASH BASIN
5	SHOWERS
10	FOOD PREP. (MISCELLANEOUS)
11	DISHWASHER
13	GALLEY
15	SPUD PEEL
16	BAKE SHOP
19	SCUL SINK
20	SCUL DR
21	POT ROOM
30	LAUNDRY
62	PIPE SHOP
66	PRINT SHOP

NO.	CATEGORY	UNITS	NO.	CATEGORY	UNITS
1	PH	UNIT	27	CHROMIUM	MG/L
2	DO	MG/L	28	COPPER	MG/L
3	TURBIDITY	JTU	29	IRON	MG/L
4	TSS	MG/L	30	LEAD	MG/L
5	TVSS	MG/L	31	MAGNESIUM	MG/L
6	TS	MG/L	32	MANGANESE	MG/L
7	TVS	MG/L	33	MERCURY	MG/L
8	TDS	MG/L	34	NICKEL	MG/L
9	SS	MG/L	35	POTASSIUM	MG/L
10	BOD	MG/L	36	SELENIUM	MG/L
11	COD	MG/L	37	SILVER	MG/L
12	TOC	MG/L	38	SODIUM	MG/L
13	OIL+GREASE	MG/L	39	ZINC	MG/L
14	PHENOLS	MG/L	40	TOT. COL.	MF-#/100ML
15	MBAS	MG/L	41	FECAL COL.	MF-#/100ML
16	N-AMMONIA	MG/L NH3-N	42	STD. PLATE	#/100ML
17	N-NITRATE	MG/L NO3-N	43	TNT	MG/L
18	N-NITRITE	MG/L NO2-N	44	CYANIDE	MG/L
19	N-KJELDAHL	MG/L N	45	RADIONUCS.	PICOCURIES
20	ORTHOPHOS	MG/L P	46	SOL. BOD	MG/L
21	PHOSPHORUS	MG/L P	47	SOL. COD	MG/L
22	ALUMINUM	MG/L	48	SALINITY	MG/L NA CL
23	ARSENIC	MG/L	49	ALK./ACID.	MG/L CACO3
24	BARIUM	MG/L	50	RES. CL	PPM
25	CADMIUM	MG/L	51	CHLORIDE	MG/L CL
26	CALCIUM	MG/L	52	SULFATE	MG/L SO4

TABLE 2-B (CONT)

UIC	DATE	SOURCE	START TIME	STOP TIME	SAMPLE TYPE	PAGE NO.	POLLUTANT CONCENTRATIONS AND CATEGORY NOS.					
												000590
												000600
												000610
												000620
04638	720530	1	0900		G	186	6.8 (1)	0.5 (2)	(3)	76. (4)	(5)	000630
04638	720530	1	0900		G	186	(6)	(7)	(8)	(9)	32. (10)	000640
04638	720530	1	0900		G	186	129. (11)	(12)	(13)	(14)	(15)	000650
04638	720530	1	0900		G	186	(16)	(17)	(18)	(19)	(20)	000660
04638	720530	1	0900		G	186	(21)	(22)	(23)	(24)	(25)	000670
04638	720530	1	0900		G	186	(26)	(27)	(28)	(29)	(30)	000680
04638	720530	1	0900		G	186	(31)	(32)	(33)	(34)	(35)	000690
04638	720530	1	0900		G	186	(36)	(37)	(38)	(39)	-3 (40)	000700
04638	720530	1	0900		G	186	100. (41)	(42)	(43)	(44)	(45)	000710
04638	720530	1	0900		G	186	(46)	(47)	289. (48)	(49)	-2 (50)	000720
04638	720530	1	0900		G	186	(51)	(52)	(53)	(54)	(55)	000730
04638	720530	1	0945		G	187	6.8 (1)	1.8 (2)	(3)	112. (4)	(5)	000740
04638	720530	1	0945		G	187	(6)	(7)	(8)	(9)	26. (10)	000750
04638	720530	1	0945		G	187	129. (11)	(12)	(13)	(14)	(15)	000760
04638	720530	1	0945		G	187	(16)	(17)	(18)	(19)	(20)	000770
04638	720530	1	0945		G	187	(21)	(22)	(23)	(24)	(25)	000780
04638	720530	1	0945		G	187	(26)	(27)	(28)	(29)	(30)	000790
04638	720530	1	0945		G	187	(31)	(32)	(33)	(34)	(35)	000800
04638	720530	1	0945		G	187	(36)	(37)	(38)	(39)	(40)	000810
04638	720530	1	0945		G	187	(41)	(42)	(43)	(44)	(45)	000820
04638	720530	1	0945		G	187	(46)	(47)	330. (48)	(49)	-2 (50)	000830
04638	720530	1	0945		G	187	(51)	(52)	(53)	(54)	(55)	000840
04638	720531	1	1430		G	253	7.5 (1)	7.7 (2)	(3)	52. (4)	(5)	000850
04638	720531	1	1430		G	253	16164. (6)	4046. (7)	16112. (8)	(9)	12. (10)	000860
04638	720531	1	1430		G	253	206. (11)	(12)	(13)	(14)	(15)	000870
04638	720531	1	1430		G	253	(16)	(17)	(18)	(19)	(20)	000880
04638	720531	1	1430		G	253	(21)	(22)	(23)	(24)	(25)	000890
04638	720531	1	1430		G	253	(26)	(27)	(28)	(29)	(30)	000900
04638	720531	1	1430		G	253	(31)	(32)	(33)	(34)	(35)	000910
04638	720531	1	1430		G	253	(36)	(37)	(38)	(39)	-3 (40)	000920
04638	720531	1	1430		G	253	(41)	(42)	(43)	(44)	(45)	000930
04638	720531	1	1430		G	253	(46)	(47)	10900. (48)	(49)	-2 (50)	000940
04638	720531	1	1430		G	253	6620. (51)	(52)	(53)	(54)	(55)	000950
04638	720608	1	1345		G	734	8.0 (1)	9.6 (2)	(3)	(4)	(5)	000960
04638	720608	1	1345		G	734	15708. (6)	3048. (7)	(8)	(9)	26. (10)	000970
04638	720608	1	1345		G	734	174. (11)	20. (12)	(13)	(14)	(15)	000980
04638	720608	1	1345		G	734	.36 (16)	-2 (17)	(18)	.30 (19)	(20)	000990
04638	720608	1	1345		G	734	.80 (21)	(22)	(23)	(24)	(25)	001000
04638	720608	1	1345		G	734	(26)	-2 (27)	.52 (28)	(29)	.09 (30)	001010
04638	720608	1	1345		G	734	488. (31)	(32)	-2 (33)	.30 (34)	(35)	001020
04638	720608	1	1345		G	734	(36)	.02 (37)	(38)	.50 (39)	2.0E+05 (40)	001030
04638	720608	1	1345		G	734	-2 (41)	(42)	(43)	(44)	(45)	001040
04638	720608	1	1345		G	734	(46)	(47)	10300. (48)	(49)	(50)	001050
04638	720608	1	1345		G	734	6250. (51)	780. (52)	(53)	(54)	(55)	001060
04638	720530	2	1215		G	191	7.8 (1)	.3 (2)	(3)	1760. (4)	(5)	001070
04638	720530	2	1215		G	191	(6)	(7)	(8)	(9)	1020. (10)	001080
04638	720530	2	1215		G	191	10010. (11)	(12)	(13)	(14)	(15)	001090
04638	720530	2	1215		G	191	(16)	(17)	(18)	(19)	(20)	001100
04638	720530	2	1215		G	191	(21)	(22)	(23)	(24)	(25)	001110
04638	720530	2	1215		G	191	(26)	(27)	(28)	(29)	(30)	001120
04638	720530	2	1215		G	191	(31)	(32)	(33)	(34)	(35)	001130
04638	720530	2	1215		G	191	(36)	(37)	(38)	(39)	5.7E+08 (40)	001140
04638	720530	2	1215		G	191	5.0E+07 (41)	(42)	(43)	(44)	(45)	001150
04638	720530	2	1215		G	191	(46)	(47)	11100. (48)	(49)	-2 (50)	001160
04638	720530	2	1215		G	191	6740. (51)	(52)	(53)	(54)	(55)	001170

TABLE 3-B - EXAMPLE OF SIERRA LIQUID WASTE DATA ANALYSIS, ALL SAMPLES

SOURCE	CATEGORY	ALL SAMPLES SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P11	P12	P13	SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P21	P22	P23	CODES
COMMODES	PH	89.	8.61	.55	89	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	DO	89.	3.46	2.89	89	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TURBIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TSS	86.	1789.22	1311.82	86	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TVSS	26.	.77	.09	26	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TS	18.	22261.94	6187.64	18	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TVS	18.	.40	.15	18	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TDS	15.	19039.66	7265.09	15	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	BOD	86.	1134.99	906.23	86	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	COD	86.	3904.40	2157.05	86	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TOC	20.	1020.35	454.98	20	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	OIL+GREASE	3.	1226.67	1016.14	3	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHENOLS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MBAS	4.	6.60	9.06	5	.20	.80	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-AMMONIA	5.	366.40	137.75	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-NITRATE	3.	1.08	.80	5	.40	.60	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-NITRITE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-KJELDAHL	4.	338.00	109.43	4	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ORTHOPHOS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHOSPHORUS	5.	119.80	105.40	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ALUMINUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ARSENIC	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	BARIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CADMIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CALCIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CHROMIUM	0.	0.00	0.00	5	1.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	COPPER	5.	1.52	.49	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	IRON	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	LEAD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MAGNESIUM	5.	536.00	49.03	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MANGANESE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MERCURY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	NICKEL	5.	.21	.08	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	POTASSIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SELENIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SILVER	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SODIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ZINC	5.	1.30	.68	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TOT. COL.	14.	.11650E+09	.21617E+09	14	0.00	1.00	0.00	0. 0.	0.		0	0.00	0.00	0.00	0,1,2,3
COMMODES	FECAL COL.	7.	.18291E+08	.26083E+08	11	0.00	.64	.36	0. 0.	0.		0	0.00	0.00	0.00	0,1,2,3
COMMODES	STD. PLATE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TNT	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CYANIDE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RADIONUCS.	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. BOD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. COD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SALINITY	38.	12244.11	1615.93	38	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ALKALINITY	9.	1429.22	2738.47	9	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ACIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RES. CL	0.	0.00	0.00	88	1.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CHLORIDE	36.	7482.75	959.38	36	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SULFATE	5.	785.80	420.42	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3

TABLE 4-B - EXAMPLE OF SIERRA LIQUID WASTE DATA ANALYSIS, WEEKDAYS VERSUS WEEKENDS

SOURCE	CATEGORY	WEEKDAYS SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P11	P12	P13	WEEKENDS SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P21	P22	P23	CODES
COMMODES	PH	75.	8.63	.59	75	0.00	1.00	0.00	14.	8.48	.41	14	0.00	1.00	0.00	11,7,8,9
COMMODES	DO	75.	4.00	2.81	75	0.00	1.00	0.00	14.	.57	.87	14	0.00	1.00	0.00	10,7,8,9
COMMODES	TURBIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TSS	72.	1732.37	1326.48	72	0.00	1.00	0.00	14.	2081.57	1237.74	14	0.00	1.00	0.00	11,7,8,9
COMMODES	TVSS	22.	.76	.09	22	0.00	1.00	0.00	4.	.83	.04	4	0.00	1.00	0.00	11,7,8,9
COMMODES	TS	16.	23072.75	6093.44	16	0.00	1.00	0.00	2.	15955.50	1967.88	2	0.00	1.00	0.00	11,7,8,9
COMMODES	TVS	16.	.41	.15	16	0.00	1.00	0.00	2.	.27	.04	2	0.00	1.00	0.00	11,7,8,9
COMMODES	TDS	13.	19707.99	7587.06	13	0.00	1.00	0.00	2.	14695.50	2151.73	2	0.00	1.00	0.00	11,7,8,9
COMMODES	SS	0.	0.00	0.00	0	0.00	0.00	0.00	1.	.09	0.00	1	0.00	1.00	0.00	0,1,2,3
COMMODES	BOD	72.	1144.22	863.60	72	0.00	1.00	0.00	14.	1023.21	1169.19	14	0.00	1.00	0.00	11,7,8,9
COMMODES	COD	73.	4101.36	2171.84	73	0.00	1.00	0.00	13.	2798.38	1759.26	13	0.00	1.00	0.00	12,7,8,9
COMMODES	TOC	18.	1036.28	446.91	18	0.00	1.00	0.00	2.	877.00	761.45	2	0.00	1.00	0.00	11,7,8,9
COMMODES	OIL+GREASE	3.	1226.67	1016.14	3	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHENOLS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MBAS	4.	6.60	9.06	4	0.00	1.00	0.00	0.	0.00	0.00	1	1.00	0.00	0.00	0,4,5,9
COMMODES	N-AMMONIA	5.	366.40	137.75	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-NITRATE	3.	1.08	.80	5	.40	.60	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-NITRITE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-KJELDAHL	4.	338.00	109.43	4	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ORTHOPHOS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHOSPHORUS	5.	119.80	105.40	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ALUMINUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ARSENIC	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	BARIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CADMIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CALCIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CHROMIUM	0.	0.00	0.00	5	1.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	COPPER	5.	1.52	.49	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	IRON	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	LEAD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MAGNESIUM	5.	536.00	49.03	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MANGANESE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MERCURY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	NICKEL	5.	.21	.08	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	POTASSIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SELENIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SILVER	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SODIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ZINC	5.	1.30	.68	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TOT. COL.	13.	.12545E+09	.22228E+09	13	0.00	1.00	0.00	1.	.13100E+06	0.	1	0.00	1.00	0.00	0,7,8,9
COMMODES	FECAL COL.	7.	.18291E+08	.26083E+08	11	0.00	.64	.36	0.	0.	0.	0	0.00	0.00	0.00	0,1,2,3
COMMODES	STD. PLATE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TNT	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CYANIDE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RADIONUCS.	1.	20000.00	0.00	1	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. BOD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. COD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SALINITY	32.	12100.81	1618.67	32	0.00	1.00	0.00	6.	13008.33	1498.81	6	0.00	1.00	0.00	11,7,8,9
COMMODES	ALKALINITY	7.	1512.86	3156.29	7	0.00	1.00	0.00	2.	1136.50	21.92	2	0.00	1.00	0.00	10,7,8,9
COMMODES	ACIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RES. CL	0.	0.00	0.00	74	1.00	0.00	0.00	0.	0.00	0.00	14	1.00	0.00	0.00	0,7,8,9
COMMODES	CHLORIDE	29.	7422.62	971.06	29	0.00	1.00	0.00	7.	7731.86	937.42	7	0.00	1.00	0.00	11,7,8,9
COMMODES	SULFATE	5.	785.80	420.42	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3

BEST AVAILABLE COPY

28-818

TABLE 5-B

EXAMPLE OF SIERRA LIQUID WASTE DATA ANALYSIS, WORKING VERSUS NONWORKING HOURS

SOURCE	CATEGORY	0600-1700 HRS SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P11	P12	P13	0-0559/1701-2359 HRS SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P21	P22	P23	CODES
COMMODES	PH	80.	8.64	.52	80	0.00	1.00	0.00	9.	8.29	.85	9	0.00	1.00	0.00	10,7,8,9
COMMODES	DO	80.	3.47	2.96	80	0.00	1.00	0.00	9.	3.39	2.25	9	0.00	1.00	0.00	11,7,8,9
COMMODES	TURBIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TSS	78.	1795.78	1335.48	78	0.00	1.00	0.00	8.	1725.25	1128.05	8	0.00	1.00	0.00	11,7,8,9
COMMODES	TVSS	23.	.77	.09	23	0.00	1.00	0.00	3.	.71	.09	3	0.00	1.00	0.00	11,7,8,9
COMMODES	TS	16.	22564.00	6490.09	16	0.00	1.00	0.00	2.	20025.50	2757.01	2	0.00	1.00	0.00	11,7,8,9
COMMODES	TVS	16.	.41	.15	16	0.00	1.00	0.00	2.	.30	.02	2	0.00	1.00	0.00	11,7,8,9
COMMODES	TDS	14.	18992.14	7536.92	14	0.00	1.00	0.00	1.	19705.00	0.00	1	0.00	1.00	0.00	0,7,8,9
COMMODES	SS	1.	.09	0.00	1	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	BOD	77.	1138.62	932.48	77	0.00	1.00	0.00	9.	1003.89	763.63	9	0.00	1.00	0.00	11,7,8,9
COMMODES	COD	78.	3918.41	2180.28	78	0.00	1.00	0.00	8.	3767.75	2045.81	8	0.00	1.00	0.00	11,7,8,9
COMMODES	TOC	19.	1008.26	464.14	19	0.00	1.00	0.00	1.	1250.00	0.00	1	0.00	1.00	0.00	0,7,8,9
COMMODES	OIL+GREASE	3.	1226.67	1016.14	3	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHENOLS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MBAS	4.	6.60	9.06	5	.20	.80	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-AMMONIA	5.	366.40	137.75	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-NITRATE	3.	1.08	.80	5	.40	.60	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-NITRITE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-KJELDAHL	4.	338.00	109.43	4	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ORTHOPHOS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHOSPHORUS	5.	119.80	105.40	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ALUMINUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ARSENIC	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	BARIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CADMIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CALCIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CHROMIUM	0.	0.00	0.00	5	1.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	COPPER	5.	1.52	.49	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	IRON	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	LEAD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MAGNESIUM	5.	536.00	49.03	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MANGANESE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MERCURY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	NICKEL	5.	.21	.08	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	POTASSIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SELENIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SILVER	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SODIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ZINC	5.	1.30	.68	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TOT. COL.	14.	.11650E+09	.21617E+09	14	0.00	1.00	0.00	0.	0.	0.	0	0.00	0.00	0.00	0,1,2,3
COMMODES	FECAL COL.	6.	.21339E+08	.27173E+08	10	0.00	.60	.40	1.	3800.0	0.	1	0.00	1.00	0.00	0,7,8,9
COMMODES	STD. PLATE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TNT	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CYANIDE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RADIONUCS.	1.	20000.00	0.00	1	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. BOD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. COD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SALINITY	31.	12087.94	1402.47	31	0.00	1.00	0.00	7.	12935.71	2363.03	7	0.00	1.00	0.00	10,7,8,9
COMMODES	ALKALINITY	8.	1502.87	2918.01	8	0.00	1.00	0.00	1.	840.00	0.00	1	0.00	1.00	0.00	0,7,8,9
COMMODES	ACIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RES. CL	0.	0.00	0.00	79	1.00	0.00	0.00	0.	0.00	0.00	9	1.00	0.00	0.00	0,7,8,9
COMMODES	CHLORIDE	29.	7393.55	816.89	29	0.00	1.00	0.00	7.	7852.29	1434.29	7	0.00	1.00	0.00	10,7,8,9
COMMODES	SULFATE	5.	785.80	420.42	5	0.00	1.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3

28-818

TABLE 6-B

EXAMPLE OF SIERRA LIQUID WASTE DATA ANALYSIS, COMPOSITE VERSUS GRAB SAMPLES

		COMPOSITE SAMPLES							GRAB SAMPLES							
SOURCE	CATEGORY	SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P11	P12	P13	SAMPLE SIZE	MEAN	STD.DEV.	TOTAL SAMPLE	P21	P22	P23	CODES
COMMODES	PH	0.	0.00	0.00	0	0.00	0.00	0.00	89.	8.61	.56	89	0.00	1.00	0.00	0,1,2,3
COMMODES	DO	0.	0.00	0.00	0	0.00	0.00	0.00	89.	3.46	2.89	89	0.00	1.00	0.00	0,1,2,3
COMMODES	TURBIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TSS	0.	0.00	0.00	0	0.00	0.00	0.00	86.	1789.22	1311.82	86	0.00	1.00	0.00	0,1,2,3
COMMODES	TVSS	0.	0.00	0.00	0	0.00	0.00	0.00	26.	.77	.09	26	0.00	1.00	0.00	0,1,2,3
COMMODES	TS	0.	0.00	0.00	0	0.00	0.00	0.00	18.	22281.94	6187.64	18	0.00	1.00	0.00	0,1,2,3
COMMODES	TVS	0.	0.00	0.00	0	0.00	0.00	0.00	18.	.40	.15	18	0.00	1.00	0.00	0,1,2,3
COMMODES	TDS	0.	0.00	0.00	0	0.00	0.00	0.00	15.	19039.66	7265.09	15	0.00	1.00	0.00	0,1,2,3
COMMODES	SS	0.	0.00	0.00	0	0.00	0.00	0.00	1.	.09	0.00	1	0.00	1.00	0.00	0,1,2,3
COMMODES	BOD	0.	0.00	0.00	0	0.00	0.00	0.00	85.	1124.52	913.27	86	0.00	1.00	0.00	0,1,2,3
COMMODES	COD	0.	0.00	0.00	0	0.00	0.00	0.00	85.	3904.40	2157.05	86	0.00	1.00	0.00	0,1,2,3
COMMODES	TOC	0.	0.00	0.00	0	0.00	0.00	0.00	20.	1020.35	454.98	20	0.00	1.00	0.00	0,1,2,3
COMMODES	OIL+GREASE	0.	0.00	0.00	0	0.00	0.00	0.00	3.	1226.67	1016.14	3	0.00	1.00	0.00	0,1,2,3
COMMODES	PHENOLS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MBAS	0.	0.00	0.00	0	0.00	0.00	0.00	4.	6.60	9.06	5	.20	.80	0.00	0,1,2,3
COMMODES	N-AMMONIA	0.	0.00	0.00	0	0.00	0.00	0.00	5.	366.40	137.75	5	0.00	1.00	0.00	0,1,2,3
COMMODES	N-NITRATE	0.	0.00	0.00	0	0.00	0.00	0.00	3.	1.08	.80	5	.40	.60	0.00	0,1,2,3
COMMODES	N-NITRITE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	N-KJELDAHL	0.	0.00	0.00	0	0.00	0.00	0.00	4.	338.00	109.43	4	0.00	1.00	0.00	0,1,2,3
COMMODES	ORTHOPHOS	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	PHOSPHORUS	0.	0.00	0.00	0	0.00	0.00	0.00	5.	119.80	105.40	5	0.00	1.00	0.00	0,1,2,3
COMMODES	ALUMINUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ARSENIC	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	BARIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CADMIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CALCIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CHROMIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	5	1.00	0.00	0.00	0,1,2,3
COMMODES	COPPER	0.	0.00	0.00	0	0.00	0.00	0.00	5.	1.52	.49	5	0.00	1.00	0.00	0,1,2,3
COMMODES	IRON	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	LEAD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MAGNESIUM	0.	0.00	0.00	0	0.00	0.00	0.00	5.	536.00	49.03	5	0.00	1.00	0.00	0,1,2,3
COMMODES	MANGANESE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	MERCURY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	NICKEL	0.	0.00	0.00	0	0.00	0.00	0.00	5.	.21	.08	5	0.00	1.00	0.00	0,1,2,3
COMMODES	POTASSIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SELENIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SILVER	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SODIUM	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	ZINC	0.	0.00	0.00	0	0.00	0.00	0.00	5.	1.30	.68	5	0.00	1.00	0.00	0,1,2,3
COMMODES	TOT. COL.	0. 0.		0.	0	0.00	0.00	0.00	14.	.11650E+09	.21617E+09	14	0.00	1.00	0.00	0,1,2,3
COMMODES	FECAL COL.	0. 0.		0.	0	0.00	0.00	0.00	7.	.18291E+08	.26083E+08	11	0.00	.64	.36	0,1,2,3
COMMODES	STD. PLATE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	TNT	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	CYANIDE	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RADIONUCS.	0.	0.00	0.00	0	0.00	0.00	0.00	1.	20000.00	0.00	1	0.00	1.00	0.00	0,1,2,3
COMMODES	SOL. BOD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SOL. COD	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	SALINITY	0.	0.00	0.00	0	0.00	0.00	0.00	38.	12244.11	1615.93	38	0.00	1.00	0.00	0,1,2,3
COMMODES	ALKALINITY	0.	0.00	0.00	0	0.00	0.00	0.00	9.	1429.22	2738.47	9	0.00	1.00	0.00	0,1,2,3
COMMODES	ACIDITY	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	0	0.00	0.00	0.00	0,1,2,3
COMMODES	RES. CL	0.	0.00	0.00	0	0.00	0.00	0.00	0.	0.00	0.00	38	1.00	0.00	0.00	0,1,2,3
COMMODES	CHLORIDE	0.	0.00	0.00	0	0.00	0.00	0.00	36.	7482.75	959.38	36	0.00	1.00	0.00	0,1,2,3
COMMODES	SULFATE	0.	0.00	0.00	0	0.00	0.00	0.00	5.	785.30	420.42	5	0.00	1.00	0.00	0,1,2,3

TABLE 7-B - EXAMPLE OF USS SIERRA (AD 18) CONCENTRATIONS, IN PORT

CATEGORY	UNITS	COMMODES	URINALS	WASH BASIN	SHOWERS	[illegible]		SPUD PEEL
PH	UNIT	.861E+01	.880E+01	.740E+01	.659E+01	.946E+01	.714E+01	.662E+01
DO	MG/L	.346E+01	.324E+01	.279E+01	.112E+01	.592E+01	.471E+01	.255E+01
TURBIDITY	JTU	0.	0.	0.	0.	0.	0.	0.
TSS	MG/L	.172E+04	.979E+03	.882E+02	.131E+03	.204E+03	.410E+03	.160E+04
TVSS	PERCENT	.770E+00	.430E+00	.580E+00	.540E+00	.720E+00	.830E+00	.690E+00
TS	MG/L	.223E+05	.170E+05	.331E+03	.345E+03	.154E+04	.864E+04	.400E+04
TVS	PERCENT	.400E+00	.300E+00	.510E+00	.430E+00	.530E+00	.520E+00	.660E+00
TDS	MG/L	.190E+05	.164E+05	.269E+03	.208E+03	.144E+04	.795E+04	.239E+04
SS	MG/L	0.	0.	0.	0.	0.	0.	0.
BOD	MG/L	.113E+04	.117E+04	.109E+03	.157E+03	.441E+03	.582E+03	.110E+04
COD	MG/L	.390E+04	.263E+04	.243E+03	.328E+03	.103E+04	.172E+04	.266E+04
TOC	MG/L	.102E+04	.225E+04	.163E+03	0.	.263E+03	.322E+03	.135E+04
OIL+GREASE	MG/L	.123E+04	.727E+03	.220E+03	0.	.582E+03	.438E+03	.930E+03
PHENOLS	MG/L	0.	0.	0.	0.	0.	0.	0.
MBAS	MG/L	.660E+01	.253E+01	.300E+00	0.	.105E+01	.500E+00	.111E+02
N-AMMONIA	MG/L NH3-N	.366E+03	.573E+03	.690E+00	0.	.750E+00	.354E+01	.100E+01
N-NITRATE	MG/L NO3-N	.108E+01	.219E+01	.360E+00	0.	.101E+01	.112E+01	0.
N-NITRITE	MG/L NO2-N	0.	0.	0.	0.	0.	.220E+01	0.
N-KJELDAHL	MG/L N	.338E+03	.203E+03	.224E+01	0.	.364E+01	.272E+01	.730E+01
ORTHOPHOS	MG/L P	0.	0.	0.	0.	0.	0.	0.
PHOSPHORUS	MG/L P	.120E+03	.554E+02	.145E+02	0.	.111E+03	.631E+01	.199E+03
ALUMINUM	MG/L	0.	0.	0.	0.	0.	0.	0.
ARSENIC	MG/L	0.	0.	0.	0.	0.	0.	0.
BARIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
CADMIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
CALCIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
CHROMIUM	MG/L	0.	0.	0.	0.	.140E+00	.400E-01	0.
COPPER	MG/L	.152E+01	.750E+00	.250E+00	0.	.321E+01	.450E+00	.780E+00
IRON	MG/L	0.	0.	0.	0.	0.	0.	0.
LEAD	MG/L	0.	0.	0.	0.	0.	0.	0.
MAGNESIUM	MG/L	.536E+03	.136E+03	.663E+01	0.	.266E+01	.311E+03	.460E+01
MANGANESE	MG/L	0.	0.	0.	0.	0.	0.	0.
MERCURY	MG/L	0.	0.	0.	0.	0.	0.	0.
NICKEL	MG/L	.210E+00	.120E+00	.600E-01	0.	.500E-01	.900E-01	.800E-01
POTASSIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
SELENIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
SILVER	MG/L	0.	0.	0.	0.	0.	0.	0.
SODIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
ZINC	MG/L	.130E+01	.690E+00	.430E+00	0.	.107E+01	.890E+00	.438E+01
TOT. COL.	MF-#/100ML	.116E+09	.788E+05	.870E+05	.501E+05	.431E+05	.306E+05	.153E+05
FECAL COL.	MF-#/100ML	.183E+08	.157E+04	.235E+04	.101E+05	.206E+03	.136E+04	0.
STD. PLATE	#/100ML	0.	0.	0.	0.	0.	0.	0.
TNT	MG/L	0.	0.	.580E+02	0.	0.	0.	0.
CYANIDE	MG/L	0.	0.	0.	0.	0.	0.	0.
RADIONUCS.	PICOCURIES	0.	0.	0.	0.	0.	0.	0.
SOL. BOD	PERCENT	0.	0.	0.	0.	0.	0.	0.
SOL. COD	PERCENT	0.	0.	0.	0.	0.	0.	0.
SALINITY	MG/L NA CL	.122E+05	.123E+05	.834E+02	.883E+02	.123E+03	.503E+04	.136E+04
ALKALINITY	MG/L CACO3	.143E+04	.489E+04	.605E+02	0.	.536E+03	.880E+00	0.
ACIDITY	MG/L CACO3	0.	0.	0.	0.	.490E+02	.181E+03	.985E+02
RES. CL	PPM	0.	0.	0.	0.	.580E+01	0.	0.
CHLORIDE	MG/L CL	.748E+04	.724E+04	.513E+02	.533E+02	.727E+02	.305E+04	.995E+03
SULFATE	MG/L SO4	.786E+03	.462E+03	.354E+02	0.	.194E+02	.394E+03	.240E+02

Note: Q value of 0.indicates no data available.

TABLE 8-B - EXAMPLE OF USS SIERRA (AD 18) CONCENTRATIONS, IN PORT, AVERAGE LB/D

CATEGORY	UNITS	COMMODES	URINALS	WASH BASIN	SHOWERS	DISHWASHER	GALLEY	SPUD PEEL
PH	UNIT	.861E+01	.880E+01	.740E+01	.659E+01	.946E+01	.714E+01	.662E+01
DO	MG/L	.346E+01	.324E+01	.279E+01	.112E+01	.592E+01	.471E+01	.255E+01
TURBIDITY	JTU	0.	0.	0.	0.	0.	0.	0.
TSS	LBS/DAY	.706E+01	.579E+00	.259E+00	.957E+00	.159E+01	.787E+01	.528E+00
TVSS	PERCENT	.770E+00	.430E+00	.580E+00	.640E+00	.720E+00	.830E+00	.690E+00
TS	LBS/DAY	.223E+05*	.170E+05*	.331E+03	.345E+03	.120E+02	.166E+03	.131E+01
TVS	PERCENT	.400E+00	.300E+00	.510E+00	.430E+00	.530E+00	.520E+00	.660E+00
TDS	MG/L	.190E+05	.164E+05	.269E+03	.208E+03	.144E+04	.795E+04	.239E+04
SS	MG/L	0.	0.	0.	0.	0.	0.	0.
BOD	LBS/DAY	.448E+01	.693E+00	.320E+00	.115E+01	.345E+01	.112E+02	.362E+00
COD	LBS/DAY	.154E+02	.156E+01	.714E+00	.240E+01	.807E+01	.329E+02	.876E+00
TOC	LBS/DAY	.402E+01	.133E+01	.479E+00	0.	.206E+01	.618E+01	.444E+00
OIL+GREASE	LBS/DAY	.484E+01	.430E+00	.645E+00	0.	.455E+01	.840E+01	.306E+00
PHENOLS	MG/L	0.	0.	0.	0.	0.	0.	0.
MBAS	LBS/DAY	.260E-01	.150E-02	.880E-03	0.	.820E-02	.960E-02	.365E-02
N-AMMONIA	LBS/DAY	.145E+01	.398E+00	.202E-02	0.	.586E-02	.680E-01	.329E-03
N-NITRATE	LBS/DAY	.426E-02	.130E-02	.106E-02	0.	.789E-02	.215E-01	0.
N-NITRITE	LBS/DAY	0.	0.	0.	0.	0.	.422E-01	0.
N-KJELDAHL	LBS/DAY	.133E+01	.120E+00	.657E-02	0.	.284E-01	.522E-01	.240E-02
ORTHOPHOS	MG/L P	0.	0.	0.	0.	0.	0.	0.
PHOSPHORUS	LBS/DAY	.472E+00	.328E-01	.425E-01	0.	.865E+00	.121E+00	.654E-01
ALUMINUM	MG/L	0.	0.	0.	0.	0.	0.	0.
ARSENIC	MG/L	0.	0.	0.	0.	0.	0.	0.
BARIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
CADMIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
CALCIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
CHROMIUM	MG/L	0.	0.	0.	0.	.140E+00	.400E-01	0.
COPPER	MG/L	.152E+01	.750E+00	.250E+00	0.	.321E+01	.450E+00	.780E+00
IRON	MG/L	0.	0.	0.	0.	0.	0.	0.
LEAD	MG/L	0.	0.	0.	0.	0.	0.	0.
MAGNESIUM	MG/L	.536E+03	.136E+03	.563E+01	0.	.266E+01	.311E+03	.460E+01
MANGANESE	MG/L	0.	0.	0.	0.	0.	0.	0.
MERCURY	MG/L	0.	0.	0.	0.	0.	0.	0.
NICKEL	MG/L	.210E+00	.120E+00	.600E-01	0.	.500E-01	.900E-01	.800E-01
POTASSIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
SELENIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
SILVER	MG/L	0.	0.	0.	0.	0.	0.	0.
SODIUM	MG/L	0.	0.	0.	0.	0.	0.	0.
ZINC	MG/L	.130E+01	.690E+00	.430E+00	0.	.107E+01	.690E+00	.438E+01
TOT. COL.	MF-#/100ML	.115E+09	.788E+05	.870E+05	.501E+05	.431E+05	.306E+05	.153E+05
FECAL COL.	MF-#/100ML	.183E+08	.157E+04	.235E+04	.101E+05	.206E+03	.136E+04	0.
STD. PLATE	#/100ML	0.	0.	0.	0.	0.	0.	0.
TNT	MG/L	0.	0.	.580E+02	0.	0.	0.	0.
CYANIDE	MG/L	0.	0.	0.	0.	0.	0.	0.
RADIONUCS.	PICOCURIES	0.	0.	0.	0.	0.	0.	0.
SOL. BOD	PERCENT	0.	0.	0.	0.	0.	0.	0.
SOL. COD	PERCENT	0.	0.	0.	0.	0.	0.	0.
SALINITY	MG/L NA CL	.122E+05	.123E+05	.834E+02	.883E+02	.123E+03	.503E+04	.136E+04
ALKALINITY	MG/L CACO3	.143E+04	.489E+04	.605E+02	0.	.536E+03	.880E+00	0.
ACIDITY	MG/L CACO3	0.	0.	0.	0.	.490E+02	.181E+03	.985E+02
RES. CL	PPM	0.	0.	0.	0.	.580E+01	0.	0.
CHLORIDE	MG/L CL	.748E+04	.724E+04	.513E+02	.533E+02	.727E+02	.305E+04	.995E+03
SULFATE	MG/L SO4	.786E+03	.462E+03	.354E+02	0.	.194E+02	.394E+03	.240E+02

Note: Q value of 0. indicates no data available.

28-818

INITIAL DISTRIBUTION

Volume I

Copies	
1	CNO (OP 45)
1	CINCLANTFLT
2	NAVMAT 1 (MAT 0342) 1 (MAT 044P)
10	NAVSHIPS 2 (SHIPS 031) 2 (SHIPS 03412B)* 1 (SHIPS 044P) 2 (SHIPS 2052) 1 (SHIPS 427) 1 (PMS 377) 1 (PMS 391)
3	NAVFAC 1 (Code 03412B) 1 (Code 090E) 1 (Code 0415)
2	NCEL (Code L70)
1	NAVSEC (SEC 6159)
1	NAVSECPHILADIV (Code 6700)

CENTER DISTRIBUTION

Copies	Code
1	(1860)
1	(1863)
1	(2701)
1	(28)
10	(2860)
20	(5614)
1	(564)
2	(5811)

Volume II

Copies	
2	NAVSHIPS 1 (SHIPS 03412B)* 1 (SHIPS 044P)
1	NCEL (Code L70)

Copies	Code
1	(1863)
6	(2860)
12	(5614)

*Addressee.

Security Classification Unclassified

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Naval Ship Research and Development Center
Annapolis, Maryland 21402

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

Nonoily Aqueous Waste Streams on USS SIERRA (AD 18), Volume~~s~~ I ~~and II~~

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Research and Development

5. AUTHOR(S) (First name, middle initial, last name)

A. Talts, D. Decker, and W. Hoffmann

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 1974	Both volumes 365	8

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

Task Area YF 53 554 002

c. Task 65502

Work Unit 1-2860-501-30

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

4182

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

28-818

10. DISTRIBUTION STATEMENT Distribution limited to U. S. Government agencies only; Test and Evaluation; April 1974. Other requests for this document must be referred to Commander, Naval Ship Systems Command (SHIPS 03412B), Washington, D. C. 20362.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

NAVSHIPS

13. ABSTRACT

The nonoily waste-water streams aboard USS SIERRA (AD 18) originating from the crew's head, galley (and scullery), laundry, pipe shop, and print shop have been characterized. The data have been used to develop mass emission factors for selected parameters in these waste-water streams. Projections have been made to the total ship for total nonoily waste-water discharges for normal in-port operations.

Data collected aboard other ships surveyed under this program (USS O'HARE (DD 889), USS SEATTLE (AOE 3), and USS INDEPENDENCE (CV 62)) are being similarly analyzed and correlated. Corroboration and validation of mass emission factors must be accomplished by the characterization of the total flow and all subflows deriving from a ship of comparable size.

(Authors)

Security Classification Unclassified

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Navy environmental protection						
Data base						
Shipboard wastes						
Nonoily liquid pollutants						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification